

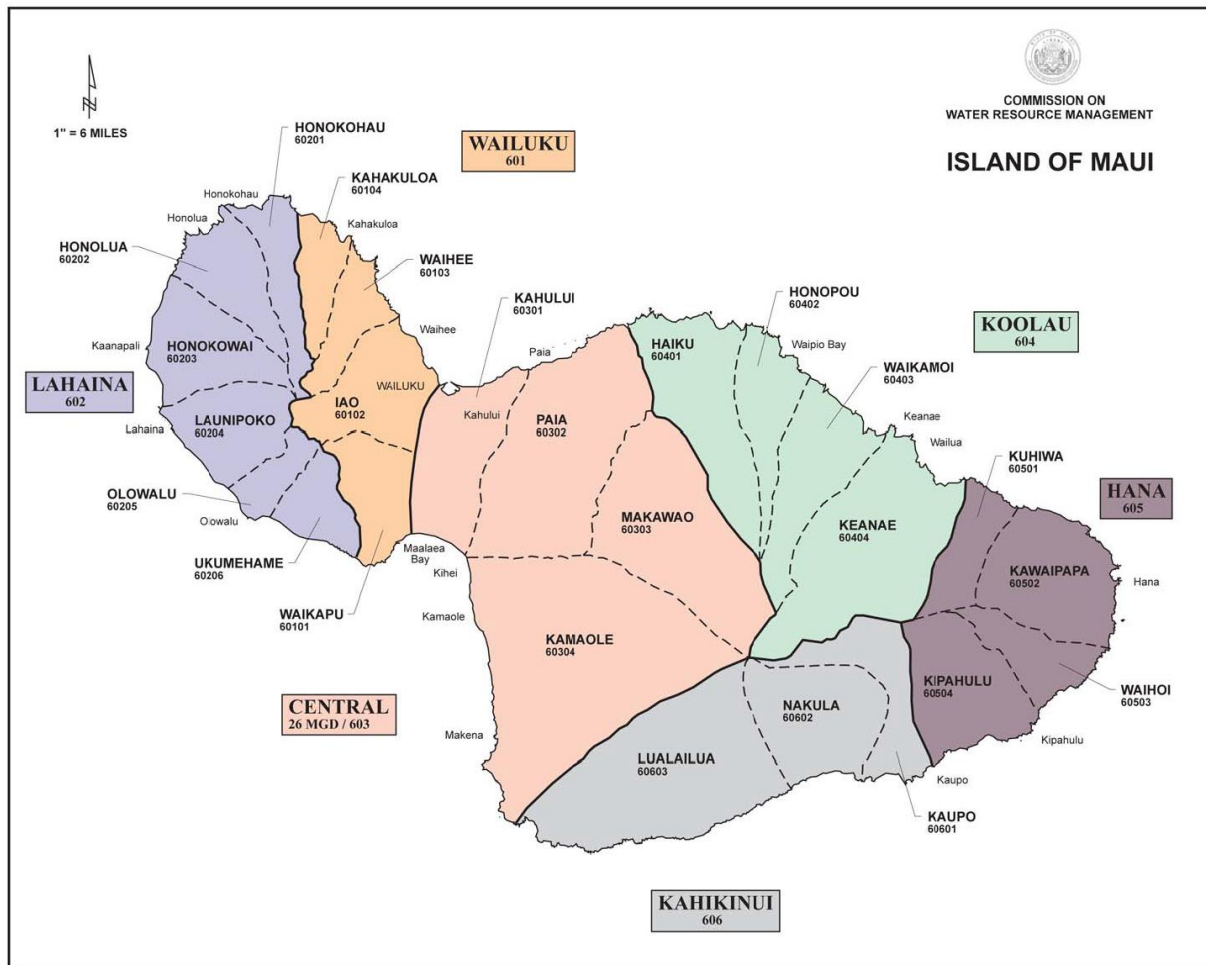
PART I

INTRODUCTION AND TECHNICAL APPROACH

INTRODUCTION

The Water Use and Development Plan (WUDP) is part of the *Hawai'i Water Plan* which serves as a comprehensive, long-range planning guide for use by the Commission on Water Resource Management (CWRM) for the protection, conservation, and management of Hawai'i's water resources. The WUDP aids CWRM and the County in the conservation, development, and use of the water resources of the County. The Maui County WUDP was adopted by Maui County ordinance and endorsed by the Mayor on October 19, 1990 and accepted by the CWRM on November 14, 1990 and is being incrementally updated for each island. This document is the Maui Island WUDP, a component of the Maui County WUDP. The plan is based on hydrologic units as required by the State Water Code and the planning period extends to 2035. There are six Aquifer Sector Areas with a total sustainable yield of 427 million gallons per day (mgd) of groundwater.

Figure 1-1 Commission on Water Resource Management Aquifer Management Sectors and Systems



Water Resources Protection Plan, 2008

1.0 REGULATORY FRAMEWORK

1.1 State Regulatory Framework

State Constitution

Under Article XI, Section 7, of the State Constitution, “The State has an obligation to protect, control, and regulate the use of Hawai'i's water resources for the benefit of its people.” This is the essence the Public Trust Doctrine which considers both the public's right to use and enjoy trust resources, and the private property rights that may exist in the use and possession of trust resources. However, the balancing of public and private interests begins with a presumption in favor of public use, access, and enjoyment.

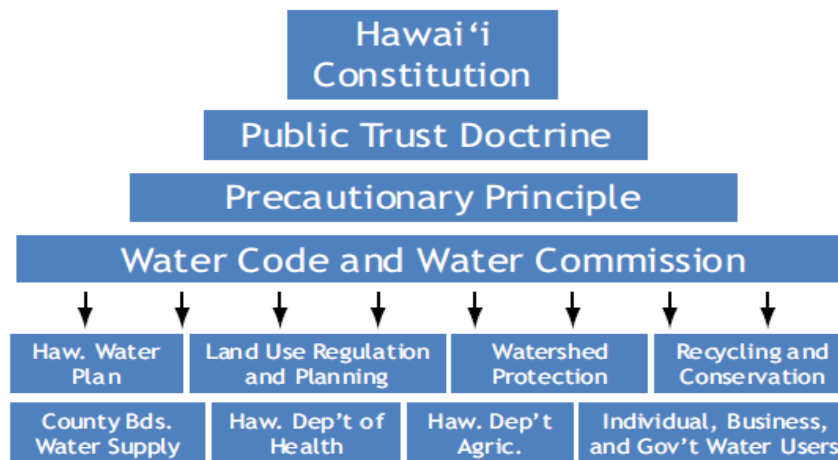
State Water Code

In 1987, the State Legislature passed the State Water Code (Hawai'i Revised Statutes, Chapter 174-C) to “protect, control, and regulate the use of Hawai'i's water resources for the benefit of its People.” It provided for a Commission on Water Resource Management (CWRM) to administer the Water Code and protect and enhance the water resources of the state of Hawai'i through wise and responsible management.

HRS §174-C-2(c) specifies, “The state water code shall be liberally interpreted to obtain maximum beneficial use of the waters of the State for purposes such as domestic uses, aquaculture uses, irrigation and other agricultural uses, power development, and commercial and industrial uses. However, adequate provision shall be made for the protection of traditional and customary Hawaiian rights, the protection and procreation of fish and wildlife, the maintenance of proper ecological balance and scenic beauty, and the preservation and enhancement of waters of the State for municipal uses, public recreation, public water supply, agriculture, and navigation. Such objectives are declared to be in the public interest.” The CWRM is charged with balancing public trust purposes and other beneficial uses.

The Water Code required formulation of a Hawai'i Water Plan, which serves as a dynamic, long range planning guide for the Commission in its functions through an integrated program for the protection, conservation, and management of the waters of the State. The *Hawai'i Water Plan* consists of the *Water Resource Protection Plan*, *Water Quality Plan*, *State Water Projects Plan*, *Agricultural Water Use and Development Plan* (AWUDP), and County Water Use and Development Plans (WUDP) prepared by each county and adopted by its county council and the CWRM.

Figure1-2 Law and Policy Framework for Water Resource Management in Hawai'i



Hawai'i Climate Change Adaptation Priority Guidelines, Figure 7, Law and Policy Framework for Water Resource Management in Hawai'i

Public Trust Doctrine

The Hawai'i Supreme Court has identified four trust purposes which are equally protected under the law, three in the Waiahole Water Case, and a fourth in its 2004 decision, *In the Matter of the Contested Case Hearing on Water Use, Well Construction, and Pump Installation Permit Applications*, filed by Waiola o Moloka'i, Inc. and Moloka'i Ranch, Limited.

- Maintenance of waters in their natural state;
- Domestic water use of the general public, particularly drinking water;
- The exercise of Native Hawaiian and traditional and customary rights, including appurtenant rights; and
- Reservations of water for Hawaiian Home Land allotments.

The Court also identified the following principles for the water resources trust, which apply to both surface and ground water resources.

- The State has both the authority and duty to preserve the rights of present and future generations in the waters of the State;
- This authority empowers the State to revisit prior diversions and allocations, even those made with due consideration of their effect on the public trust;
- The State also bears the affirmative duty to take the public trust into account in the planning and allocation of water resources and to protect public trust uses whenever feasible;

- Competing public and private water uses must be weighed on a case-by-case basis, and any balancing between public and private purposes begins with a presumption in favor of public use, access, and enjoyment;
- There is a higher level of scrutiny for private commercial uses, with the burden ultimately lying with those seeking or approving such uses to justify them in light of the purposes protected by the trust; and
- Reason and necessity dictate that the public trust may have to accommodate uses inconsistent with the mandate of protection, to the unavoidable impairment of public instream uses and values. Offstream use is not precluded but requires that all uses, offstream or instream, public or private, promote the best economic and social interests of the people of the State.

The Precautionary Principle

The precautionary principle (or precautionary approach) states that if an action or policy has a suspected risk of causing harm to the public or to the environment, in the absence of a consensus on scientific evidence that the action or policy is not harmful, the burden of proof that it is *not* harmful falls on those taking an action that may or may not be a risk to public or environmental health. The principle is used by policy makers to justify discretionary decisions in situations where there is the possibility of harm from making a certain decision (e.g. taking a particular course of action) when extensive scientific knowledge on the matter is lacking. The principle implies that there is a social responsibility to protect the public from exposure to harm, when scientific investigation has found a plausible risk. These protections can be relaxed only if further scientific findings emerge that provide sound evidence that no harm will result. The MIP requires that Native Hawaiian water rights be incorporated into water planning, but there is presently a lack of scientifically-based in-stream flow standards which relate to water rights and public trust purposes and planning for surface water resources. Thus, in this case the precautionary principle applies due to a lack of scientifically-based information upon which to base decisions.

According to the State of Hawai'i Water Plan, Water Resources Protection Plan, when scientific evidence is preliminary and not conclusive regarding the management of the water resources trust, it is prudent to adopt "precautionary principles." The Hawai'i Supreme Court's interpretation as explained in the Waiahole Water Case is as follows:

- As with any general principle, its meaning must vary according to the situation and can only develop over time. At a minimum, the absence of firm scientific proof should not tie the Water Commission's hands in adopting reasonable measures designed to further the public interest.
- The precautionary principle simply restates the commission's duties under the State Constitution and the State Code. The lack of full scientific certainty does not extinguish the presumption in favor of public trust purposes or vitiates the Water Commission's affirmative duty to protect such purposes wherever feasible. Nor does its present

inability to fulfill the instream use protection framework render the statute's directives any less mandatory. In requiring the Water Commission to establish instream flow standards at an early planning stage, the State Water Code contemplates the designation of the standards based not only on scientifically proven facts, but also on future predictions, generalized assumptions, and policy judgments. Neither the State Constitution nor the State Water Code constrains the Water Commission to wait for full scientific certainty in fulfilling its duty toward the public interest in minimum instream flows.

The Court's linking of the Public Trust Doctrine to the precautionary principle offers significant guidance to water resource management. The tenets of the precautionary principle state that:

- There is a duty to take anticipatory action to prevent harm to public resources;
- There is an obligation to examine the full range of alternatives before starting a new activity and in using new technologies, processes, and chemicals; and
- Decisions should be open, informed, and democratic and include affected parties.

In this regard, "precautionary actions" may include:

- Anticipatory and preventive actions;
- Actions that increase rather than decrease options;
- Actions that can be monitored and reversed;
- Actions that increase resilience, health, and the integrity of the whole system; and
- Actions that enhance diversity.

The Public Trust Doctrine establishes a general duty to take precautionary actions and thus shifts the burden of proof to non-trust purposes and requires preventive action in the face of uncertainty.¹ Note that, while these principles are directed at surface water resources, they apply equally to ground water resources.

Water Rights and Uses

The State Water Code² and the common law govern water rights and uses in Hawai'i. According to the State of Hawai'i Water Plan, Water Resources Protection Plan³ the State Water Code preserved appurtenant rights but not correlative and riparian rights in designated water management areas. Thus, when a ground water management area is designated, existing correlative uses within that area can be issued water use permits under the existing use provisions of the State Water Code, but unexercised correlative rights are extinguished. Similarly, when a surface water management area is designated, existing riparian uses within that area are eligible for water use permits as existing uses, but unexercised riparian rights are

¹ State Water Resources Protection Plan, p 2-5.

² HRS 174C, §§ 174C-1 to 174C-101.

³ State Water Resources Protection Plan, p 2-6.

extinguished. Furthermore, the Hawai'i Supreme Court has ruled that when there is an undisputed, direct interrelationship between the surface and ground waters, designation of a ground water management area subjects both ground and surface water diversions from the designated area to the statutory permit requirement.⁴ Presumably, permits would also be required for ground and surface water diversions when the interrelationship occurs in a surface water management area.

While water use permits are required only in designated water management areas and the common law on water rights and uses continue to apply in non-designated areas, other provisions of the State Water Code apply throughout the state. Thus, for example, well construction and pump installation permits are required for any new or modified ground water use, and stream diversion and stream alteration permits are required for any new or modified surface water diversions. If the proposed stream diversion will affect the existing instream flow standard, a successful petition to amend the interim instream flow standard is also required.

Riparian Rights

Riparian rights are rights of land adjoining natural watercourses and are the surface water equivalent of correlative rights to ground waters; i.e., the use has to be on the riparian lands, the use has to be reasonable, and the exercise of those rights cannot actually harm the reasonable use of those waters by other riparian landowners. The Court had originally stated that the right was to the natural flow of the stream without substantial diminution and in the shape and size given it by nature⁵, but later concluded that the right should evolve in accordance with changing needs and circumstances. Thus, in order to maintain an action against a diversion which diminishes the quantity or flow of a natural watercourse, riparian owners must demonstrate actual harm to their own reasonable use of those waters.⁶

Correlative Rights

Under the common law, owners of land overlying a ground water source have the right to use that water on the overlying land, as long as the use is reasonable and does not injure the rights of other overlying landholders.⁷ When the amount of water is insufficient for all, each is limited to a reasonable share of the ground water. Overlying landowners who have not exercised their correlative rights cannot prevent other landowners from using the water on the theory that they are using more than their reasonable share. They must suffer actual, not potential, harm. Only when landowners try to exercise their correlative rights and the remaining water is insufficient to meet their needs, can they take action to require existing users to reduce their uses.

⁴ *In re Water Use Permit Applications*, 94 Haw. 97, at 173; 9 P3d 409, at 485 (2000).

⁵ *McBryde v Robinson*, 54 Haw. 174, at 198; 504 P.2d 1330, at 1344 (1973); *aff'd on rehearing*, 55 Haw. 260; 517 P.2d 26 (1973); *appeal dismissed for want of jurisdiction and cert. denied*, 417 U.S. 962 (1974).

⁶ *Reppun v Board of Water Supply*, 65 Haw. 531, at 553; 656 P.2d 57, at 72 (1982).

⁷ *City Mill Co. v Hon. S. & W. Com.*, 30 Haw. 912 (1929).

Appurtenant Rights

Appurtenant water rights are rights to the use of water utilized by parcels of land at the time of their original conversion into fee simple lands i.e., when land allotted by the 1848 Mahele was confirmed to the awardee by the Land Commission and/or when the Royal Patent was issued based on such award, the conveyance of the parcel of land carried with it the appurtenant right to water⁸. The amount of water under an appurtenant right is the amount that was being used at the time of the Land Commission award and is established by cultivation methods that approximate the methods utilized at the time of the Mahele, for example, growing wetland taro⁹. Once established, future uses are not limited to the cultivation of traditional products approximating those utilized at the time of the Mahele¹⁰, as long as those uses are reasonable, and if in a water management area, meets the State Water Code's test of reasonable and beneficial use ("the use of water in such a quantity as is necessary for economic and efficient utilization, for a purpose, and in a manner which is both reasonable and consistent with the State and county land use plans and the public interest"). As mentioned earlier, appurtenant rights are preserved under the State Water Code, so even in designated water management areas, an unexercised appurtenant right is not extinguished and must be issued a water use permit when applied for, as long as the water use permit requirements are met.

The law with regards to appurtenant rights is not clear. The Supreme Court in Reppun¹¹ held that where a landowner attempted to reserve an appurtenant right while selling the underlying land, the reservation is not valid and the attempt to reserve extinguishes the appurtenant right. In doing so, the Court reasoned that there is nothing to prevent a transferor from effectively providing that the benefit of the appurtenant right not be passed to the transferee.¹² This difference is due to the Court's interpretation that riparian rights had been created by the 1850 statute, so any attempt by the grantor to reserve riparian water rights in the deed when riparian lands are sold is invalid. Presumably, the inconsistency could be cured by legislation providing a statutory basis for appurtenant rights. In fact, the Court in the Waiahole Water Case cited to the State Water Code's recognition of appurtenant rights and legislative comment to the effect that "[a]ppurtenant rights may not be lost."¹³ However, the Court did not explicitly discuss its prior Reppun decision, so it is unclear whether its Waiahole decision overruled Reppun.

Appropriated Uses

Appropriated uses are uses of surface or ground waters on non-riparian or nonoverlying lands. In the case of ground water, "[P]arties transporting water to distant lands are deemed mere 'appropriators,' subordinate in right to overlying landowners ...[T]he correlative rights rule

⁸ 54 Haw. 174, at 188; 504 P.2d 1330, at 1339.

⁹ 65 Haw. 531, at 554; 656 P.2d 57, at 72.

¹⁰ *Peck v Bailey*, 8 Haw. 658, at 665 (1867).

¹¹ 65 Haw. 531, at 552; 656 P.2d 57, at 71 (1982).

¹² *Ibid.*

¹³ *Ibid.*

grants overlying landowners a right only to such water as necessary for reasonable use. Until overlying landowners develop an actual need to use ground water, non-overlying parties may use any available 'surplus' (citations omitted)."¹⁴ For surface waters, "the effect of permitting riparian owners to enjoin diversions beneficial to others in the absence of a demonstration of actual harm may occasionally lead to wasteful or even absurd results... The continuing use of the waters of the stream by the wrongful diversion should be contingent upon a demonstration that such use will not harm the established rights of others."¹⁵ Thus, appropriated uses are not based on water rights but are allowed as long as they are reasonable and do not actually impinge on correlative and riparian rights. Note that appurtenant uses would be a type of appropriated uses if they were not based on appurtenant rights, and that in fact, the history of appurtenant uses in the Kingdom of Hawai'i has led to their establishment as water rights superior to riparian rights. Also note that when a water management area is designated, appropriated uses become superior to unexercised water rights, because appropriated uses become existing uses and are eligible for water use permits, while unexercised correlative and riparian rights are extinguished.

Obsolete Rights: Prescriptive and Konohiki Rights

Until 1973, surface waters were treated as private property and could be owned. Prescriptive water rights were the water equivalent of "adverse possession" in land ownership, where open and hostile occupation of another's private property for a specified number of years entitled the occupier to take legal ownership, because it raised the legal presumption of a grant. Prescriptive rights to water were exercisable only against the ownership of other private parties and not against the government. Thus, under prescriptive rights, appropriated uses could ripen into a prescriptive right superior to riparian rights. (Some early Court cases viewed appurtenant rights as a type of prescriptive right.) In 1973, the Court voided private ownership of water resources and prescriptive rights because of public ownership of all surface waters¹⁶. As for ground water, two early cases (1884¹⁷ and 1896¹⁸) reflected the then prevailing law on surface waters that water could be private property, but those cases also concluded that prescriptive rights cannot be exercised against subterranean waters that have no known or defined course, i.e., you could not adversely possess what you could not see. In 1929, the Court adopted the correlative rights rule¹⁹, in which the overlying landowners could not use the water as they pleased, because it was a shared resource.

Until 1973, "konohiki lands," or lands whose title had passed from persons documented as konohiki, owned the "normal daily surplus water" in excess of waters reserved by appurtenant and prescriptive rights. (Despite a number of earlier cases, in 1930 the Court had concluded

¹⁴ 94 Haw. 97, at 178; 9 P3d 409, at 490 (2000).

¹⁵ 65 Haw. 531, at 553-554; 656 P.2d 57, at 72 (1982).

¹⁶ 54 Haw. 174; 504 P.2d 1330 (1973);

¹⁷ *Davis v Afong*, 5 Haw. 216 (1884).

¹⁸ *Wong Leong v Irwin*, 10 Haw. 265 (1896).

¹⁹ *City Mill Co. v Hon. S. & W. Com.*, 30 Haw. 912 (1929).

that riparian rights had never been the law in Hawai'i.²⁰ The 1973 Court, instead of overturning that decision, found a statutory basis for riparian rights in the 1850 statute.) In 1973, in addition to voiding any private property interest in water, the Court ruled that there can be no "normal daily surplus water," because the recognition of riparian rights entitled owners of riparian lands to have the flow of the watercourse in the shape and state given it by nature.²¹

Native Hawaiian Water Rights

The following provisions on native Hawaiian water rights are outlined in the State Water Code, HRS §174C-101:

(a) Provisions of this chapter shall not be construed to amend or modify rights or entitlements to water as provided for by the Hawaiian Homes Commission Act, 1920, as amended, and by chapters 167 and 168, relating to the Moloka'i irrigation system. Decisions of the commission on water resource management relating to the planning for regulation, management, and conservation of water resources in the State shall, to the extent applicable and consistent with other legal requirements and authority, incorporate and protect adequate reserves of water for current and foreseeable development and use of Hawaiian home lands foreseeable development and use of Hawaiian home lands as set forth in section 221 of the Hawaiian Homes Commission Act.

(b) No provision of this chapter shall diminish or extinguish trust revenues derived from existing water licenses unless compensation is made.

(c) Traditional and customary rights of ahupua'a tenants who are descendants of native Hawaiians who inhabited the Hawaiian Islands prior to 1778 shall not be abridged or denied by this chapter. Such traditional and customary rights shall include, but not be limited to, the cultivation or propagation of taro on one's own kuleana and the gathering of hihiwai, opae, o`opu, limu, thatch, ti leaf, aho cord, and medicinal plants for subsistence, cultural, and religious purposes.

(d) The appurtenant water rights of kuleana and taro lands, along with those traditional and customary rights assured in this section, shall not be diminished or extinguished by a failure to apply for or to receive a permit under this chapter.

Native Hawaiian Cultural Rights

The Hawai'i State Constitution was amended in 1978 to specifically recognize traditional and customary Hawaiian practices:

²⁰ *Territory v Gay*, 31 Haw. 376 (1930); *aff'd* 52 F.2d 356 (9th Cir. 1931); *cert. denied* 284 U.S. 677 (1931).

²¹ 54 Haw. 174, at 198; 504 P.2d 1330, at 1344 (1973).

Article XII Section 7. The State reaffirms and shall protect all rights, customarily and traditionally exercised for subsistence, cultural and religious purposes and possessed by ahupua'a tenants who are descendants of native Hawaiians who inhabited the Hawaiian Islands prior to 1778, subject to the right of the State to regulate such rights.

Traditional and Customary Rights Clarified by the Hawai'i Supreme Court

The Hawai'i Supreme Court has recognized that H.R.S. section 7-1 specifically protects the right to gather, although that right is limited to the items listed in the statute. Broader protection for the exercise of traditional and customary practices is clarified in H.R.S. section 1-1, extending those rights to the gathering of materials that are otherwise essential to a tenants way of life, including medicinal plants and upland subsistence farming practiced other the ahupua`a where Native Hawaiians regularly resided. Article XII, section 7 of the Hawai`i Constitution has been interpreted by Hawai'i courts as protecting gathering rights exercised beyond the boundaries of the ahupua'a of residence, and have held that "legitimate traditional and customary practices must be protected to the extent feasible." The state does not have the "unfettered discretion to regulate the rights of ahupua'a tenants out of existence." The state can, however, permit private property owners to exclude persons "pursuing non-traditional practices or exercising otherwise valid customary rights in an unreasonable manner" or on private property that is "fully developed."

Rights of Ahupua`a Residents

Gathering rights are protected by three sources in Hawai'i law according to the Hawai'i Supreme Court: H.R.S. sections 7-1 and 1-1, and article XII, section 7 of the Hawai'i Constitution. The court held that residents of an ahupua'a may—for the purpose of practicing Native Hawaiian customs and traditions—enter undeveloped lands within the ahupua`a to gather the items listed in H.R.S. section 7-1: "firewood, house-timber, aho cord, thatch, or ti leaf." The court also ruled that pursuant to article XII, section 7, courts are obligated "to preserve and enforce such traditional rights." It further determined that H.R.S. section 1-1 ensures the continuation of Native Hawaiian customs and traditions *not* specifically enumerated in H.R.S. section 7-1, which may have been practiced in certain ahupua`a "so long as no actual harm is done thereby."²² The court eventually ruled against Kalipi, but the case is important because it was the first in which the Hawai'i Supreme Court recognized the modern legal bases of traditional and customary rights: H.R.S. sections 7-1 and 1-1, and article XII, section 7 of the Hawai'i Constitution.²³

In summary, the court ruled that: (1) mere ownership of property within an ahupua'a is not sufficient to justify the exercise of traditional and customary rights in that ahupua'a; (2) H.R.S. section 7-1 permits only *hoa'aina* (native tenants) to gather in the ahupua`a where they live;

²² Kalipi, 66 Haw. at 10, 656 P.2d at 751.

²³ Forman, David M., Susan K. Serrano. *Ho'ohana Aku, a Ho'ola Aku: A legal primer for Traditional and Customary Rights in Hawai'i*, 2012

(3) H.R.S. section 7-1 permits only *hoa'aina* to gather the items enumerated in that statute; (4) H.R.S. section 7-1 permits only *hoa'aina* to enter undeveloped (rather than fully developed) lands for the purpose of exercising traditional and customary rights; (5) the interests of the property owner and *hoa'aina* must be balanced; and (6) H.R.S. section 1-1 protects other traditional and customary practices that have continued without harm to property owners.²⁴

Rights of Residents Outside Ahupua`a Boundaries

The Hawai'i Supreme Court held that under article XII, section 7, traditional and customary rights could be exercised for subsistence, cultural, and religious purposes on undeveloped lands beyond the *ahupua'a* of residence, provided that "such rights have been customarily and traditionally exercised in this manner."²⁵

In summary, the court held: (1) *hoa'aina* can gather beyond the *ahupua'a* in which they live, where such rights have been customarily and traditionally exercised in this manner; (2) *hoa'aina* can gather what is needed for traditional and customary Hawaiian subsistence, cultural and religious purposes; (3) *hoa'aina* may enter undeveloped lands to reasonably exercise their traditional and customary practices; and (4) the interests of the property owner and *hoa'aina* must be balanced.

Rights Exercised on Less Than Fully Developed Land

The Hawai'i Supreme Court in *Public Access Shoreline Hawaii v Hawai'i County Planning Commission (1995)* ("PASH") provided a doctrine to resolve disputes in which native Hawaiians seek to practice traditional rituals and gather materials related to their cultural practices in a reasonable manner on land that is privately owned. This modern property law, which draws from both western law and native Hawaiian custom and tradition, provides guidance on the rights and expectations of private parties, as well as on agencies.²⁶

In summary, PASH/Kohanaiki meant that: (1) *hoa'aina* can gather anywhere that such rights have been customarily and traditionally exercised in that manner; (2) *hoa'aina* can gather what is needed for traditional and customary subsistence, cultural and religious purposes; (3) *hoa'aina* can gather on land that is less than fully developed; (4) the government cannot regulate traditional and customary rights out of existence; (5) the balance weighs in favor of the property owner against *hoa'aina* who exercise otherwise valid customary rights in an unreasonable manner.

²⁴ Forman, *Ho'ohana Aku, a Ho'ola Aku: A legal primer for Traditional and Customary Rights in Hawai'i*, 12.

²⁵ Pele I, 73 Haw. at 620, 837 P.2d at 1272.

²⁶ 79 Hawai'i 425, 903 P.2d 1246. [1995]

Duty of State Agencies to Protect Native Hawaiian Traditional and Customary Rights

The Hawai'i Supreme Court in *Ka Pa'akai O Ka 'Aina v. Land Use Commission* (2000) provided an analytical framework "to effectuate the State's obligation to protect native Hawaiian customary and traditional practices while reasonably accommodating competing private [property] interests."²⁷ The Court enumerated three tests for agencies to protect traditional and customary Hawaiian practices to the extent feasible. Under this framework, state and county agencies must independently assess the following when reviewing land use applications:

- (A) The identity and scope of valued cultural and historical or natural resources in the petition area including the extent to which traditional and customary Native Hawaiian rights are exercised in the petition area;
- (B) The extent to which those resources including traditional and customary Native rights will be affected or impaired by the proposed action; and
- (C) The feasible action, if any, to be taken by the state to reasonably protect Native Hawaiian rights if they are found to exist.

For the purposes of this plan, proposed uses of water resources should be accompanied by inquiries into the impacts on traditional and customary rights to ensure that proposed water resource uses are pursued in a culturally appropriate way.

Statewide Framework for Updating the Hawai'i Water Plan

The *Statewide Framework*, 2000, provides guidance in updating WUDPs to insure a consistent and coordinated plan for the protection, conservation and management of our water resources, effective implementation by the counties, and use by the CWRM for resource management purposes. The Statewide Framework includes the following recommended plan elements for the County WUDP update process:

- County-Specific WUDP Project Description
- Coordination with CWRM on Water Resource Management
- Stakeholder and Public Involvement
- Development of Policy Objectives and Evaluation Criteria
- Description of Water System Profiles
- Identification of Resource and Facility Options
- Development and Evaluation of Strategy Options
- Implementation Plan

A revised Project Description was accepted by the CWRM in 2012 and updates to the CWRM and consultation with Commission staff have been ongoing throughout the process. The WUDP has been prepared with credible public and stakeholder involvement as outlined in this Plan

²⁷ 94 Hawai'i 31, 7 P3d 1087 (2000)

and Appendix 7. Policy objectives and evaluation criteria were developed through the lengthy public process and used to evaluate resource and facility options in order to develop a coherent and viable implementation plan. More information on the State Framework is provided in Appendix 1.

Consistency with Laws and Policies

The WUDP provides overall policies, strategies and implementation plans to guide the actions of Maui County and provide advice to CWRM regarding the planning, management, conservation, use, development, and allocation of limited surface water and ground water resources to 2035. The WUDP is intended to be part of a comprehensive and integrated framework to achieve these objectives including consistency with the following state, federal, and county laws and policy documents:

- Federal Safe Drinking Water Act
- State Constitution and State Water Code
- Hawai'i Water Plan and Statewide Framework for Updating the Hawai'i Water Plan
- Hawai'i Supreme Court Decisions on the Waiahole Ditch, the Waiola O Moloka'i, the Ka Pa'akai O Ka'aina, and Na Wai 'Eha and East Maui Streams contested cases
- State land use classifications and policies
- Maui County Code
- Maui County General Plan, Maui Island Plan, Community Plans, and Zoning Designations
- DHHL Regional and Community Plans, Land Use Designations and Water Reservations
- Other state plans or guidelines such as the Hawai'i Drought Plan, Hawai'i Water Conservation Plan and Climate Adaption Guidelines

1.2 County Regulatory Framework

Maui Island WUDP

The purpose of the WUDP is “to meet the mandate of the State Water Code relative to statewide water resources planning and aid the commission and the County in the conservation, development, and use of the water resources of the County.” Its objective is “to set forth the allocation of water to land use through the development of policies and strategies which shall guide the County in its planning, management, and development of water resources to meet projected demands.” It provides guidance to the CWRM for decision-making on water management area designation and water use and water reservation requests. At the County level, the plan serves as the primary guide to the County Council, Maui County Department of Water Supply (MDWS), and all other agencies of the County in approving or recommending the use or commitment of water resources in the County, and in using public funds to develop water resources. (Maui County Code Chapter 14.02.)

The WUDP meets the statutory requirements of HRS 174C-31 and HAR 13-7-170, the State Water Code (HRS, 174C), and Maui County Code Chapter 2.88A, and addresses the recommended elements in the Statewide Framework for updates of WUDPs. Section 13-170-31, HAR states that the WUDP shall include but not be limited to:

- (1) The status of water and related land development, including an inventory of existing water uses for domestic, municipal and industrial users, agriculture, aquaculture, hydropower development, drainage, re-use, reclamation, recharge and resulting problems and constraints;*
- (2) Future land uses and water related needs; and*
- (3) Regional plans for water development, including recommended and alternative plans, costs, adequacy of plans and relationship to Water Resources Protection and Water Quality Plans.*

Additional guidelines for preparing the WUDPs are provided in Administrative Rule §13-170-32:

- (1) Each water use and development plan shall be consistent with the water resource protection plan and the water quality plan.*
- (2) Each water use and development plan and the state water projects plan shall be consistent with the respective county land use plans and policies, including general plan and zoning as determined by each respective county.*
- (3) Each water use and development plan shall consider a twenty year projection period for analysis purposes.*
- (4) The water use and development plan for each county shall also be consistent with the state land use classification and policies.*
- (5) The cost of maintaining the water use and development plan shall be borne by the counties; state water capital improvement funds appropriated to the counties shall be deemed to satisfy Article VIII, section 5 of the State Constitution.*

The WUDP is intended to be consistent with the other elements of the Hawai'i Water Plan, the state land use classifications and polices, and County zoning and land use policies. It must also recognize Department of Hawaiian Homelands development needs. The WUDP must be periodically updated to remain consistent with these plans and policies.

The Maui County WUDP was adopted by County ordinance and by CWRM in 1990 and is being incrementally updated for each island. An update adopted by Maui County Council in 2010 was not approved by CWRM, primarily because it was limited in scope to the Maui Department of Water Supply's (DWS) Central Maui District rather than all public trust purposes. In August 2012, the CWRM accepted a revised Project Description to comprehensively address all water resources and needs for public and private water systems and public trust purposes based on the Maui Island Plan growth rate projections. This document comprises the Maui Island component of the Maui County WUDP. The Lana'i WUDP was updated in 2011 and the Moloka'i WUDP will be updated following adoption of this Maui Island WUDP.

County of Maui General Plan

The State Water Code as well as the Maui County Charter, Chapter 11, Section 8-11.2(3) mandate that County WUDPs be consistent with County land use plans and policies. The Maui Island WUDP provides policies and strategies for the protection, planning, management, and development of water resources to meet land use and projected demand development set forth in the Maui Island Plan.

The 2030 Maui County General Plan is comprised of the Countywide Policy Plan (2011), Maui Island Plan (MIP, 2012) and the Community Plans adopted in various years. The Socio-Economic Forecast for the General Plan was updated in July 2014 and the MIP Implementation Plan was adopted in 2015. The MIP provides direction for future growth, the economy, and social and environmental decisions through 2030 based on a vision founded on core values, goals, objectives, policies and actions. The MIP establishes a Directed Growth Strategy which identifies areas appropriate for future urbanization and revitalization. The WUDP does not propose alterations to existing land use and development patterns or those proposed by the MIP or Community Plans. However, the WUDP may identify land use patterns or policy directions in the MIP that make it more difficult or inefficient to meet the multiple objectives of the WUDP.

The MIP is used by County policy boards, staff and the community as a policy document for decision-making on discretionary development proposals and for developing, implementing and applying land use policies and regulations. Formulation of the WUDP has included relevant data, technical reports and resources derived from the MIP process and coordination with the Maui County Planning Department's Long Range Planning Division, which is responsible for the preparation, adoption and implementation of the MIP. In turn, projections, policies and strategies in the WUDP can inform the Community Plan updates and future MIP amendments.

The WUDP is intended to allocate water to existing and planned land use. The WUDP and the MIP make up a framework to ensure that land use and infrastructure planning are integrated and provide guidance for resource use and infrastructure development.

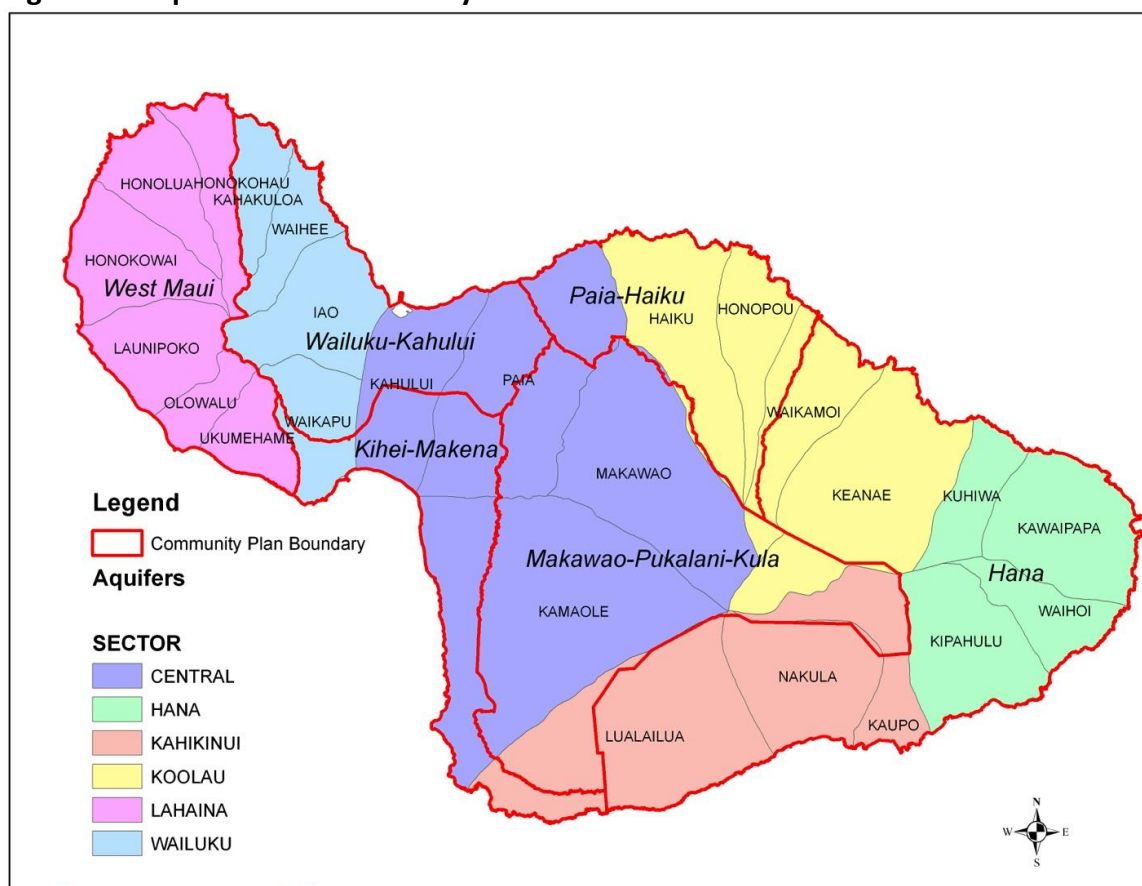
MIP policies applicable to the WUDP are listed in Appendix 2. The MIP water utility goal and objectives include:

- Goal 6.3** Maui will have an environmentally sustainable, reliable, safe, and efficient water system.
- Objective 6.3.1** More comprehensive approach to water resources planning to effectively protect, recharge, and manage water resources including watersheds, groundwater, streams, and aquifers.
- Objective 6.3.2** Increase the efficiency and capacity of the water systems in striving to meet the needs and balance the island's water needs.
- Objective 6.3.3** Improve water quality and the monitoring of public and private water.

Community Development Plans

Community Plans have been prepared for the Hāna, Pa'ia-Ha'iku, West Maui, Makawao-Pukalani-Kula, Kihei-Makena and Wailuku-Kahului areas. They address a 20-year planning period and must be updated every 10 years per Maui County Code Chapter 2.08B. Each plan provides a land use map and addresses land use, density and design, transportation, cultural resources, community facilities and infrastructure in two-year increments, visitor accommodations, commercial and residential areas and other matters related to development of the planning area. With the exception of West Maui, community plan areas are not consistent with hydrologic units which are required to form the basis for water use planning in the WUDP as shown in the figure below.

Figure 1-3 Aquifers and Community Plan Areas



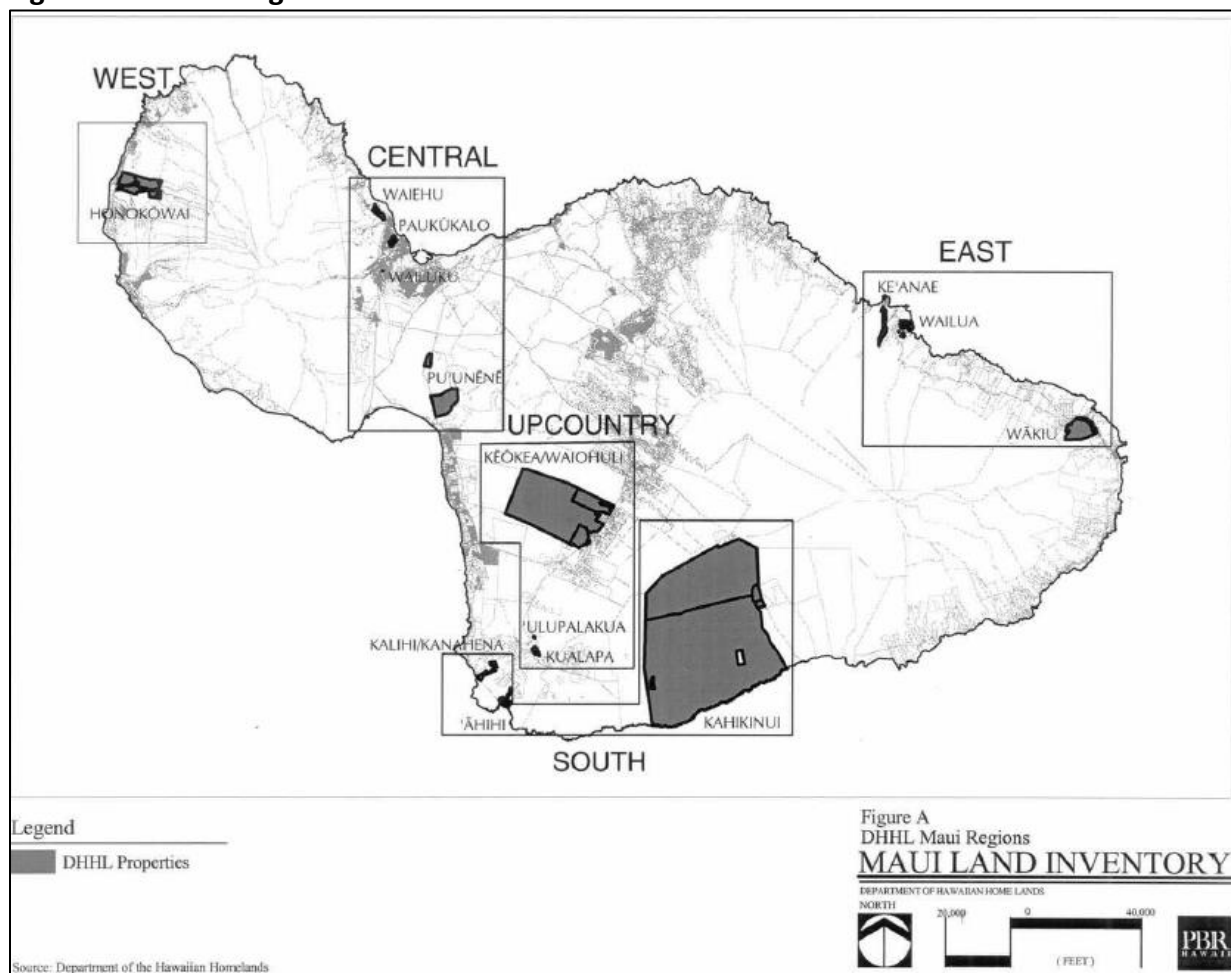
1.3 Other Policy Plans

State Department of Hawaiian Homelands (DHHL) Land Use Plans

The function of the Department of Hawaiian Home Lands (DHHL) is to serve native Hawaiians and to administer its land trust throughout the State of Hawai'i. The primary method by which

DHHL serves these beneficiaries is through 99-year homestead leases, which are land leases provided for residential, pastoral or agricultural use for the annual fee of one dollar. DHHL landholdings on Maui total more than 31,000 acres in five regions: Central Maui (Waiehu, Paukūkalo, and Pu'unēnē), West Maui (Honokōwai), Upcountry Maui (Kēōkea/Waiohuli, 'Ulupalakua, Kualapa), South Maui (Kahikinui, Kalihi/Kanahena, 'Āhihi), and East Maui (Ke'anae, Wailua, Wākiu).

Figure 1-4 DHHL Regions and Lands



DHHL developed a three-tier planning system to guide the development and use of Hawaiian homelands statewide. The Hawaiian Homes Commission adopted its Maui Island Plan as the overarching planning document in 2004. Subsequently the Kēōkea/Waiohuli, Kahikinui, Leiali'i-Honokōwai and Waiehu Kou- Paukūkalo Regional Plans were adopted. A Water Policy Plan adopted in July 2014 (Appendix 3) states that the Hawaiian Homes Commission and DHHL's mission is to strive to ensure the availability of adequate, quality water by working cooperatively to:

- Understand our trust water assets;
- Plan for our water need;

- Aggressively understand, exercise and assert our kuleana as stewards of water;
- Develop and protect water sources; and
- Manage water systems.

Issues affecting DHHL and development projects proposed by DHHL within the next 20 years are incorporated into the land use based demand projections and the planning objectives and evaluation criteria. This will address reservations for water for Hawaiian Home Land allotments which is a public trust purpose.

Hawai'i Water Conservation Plan

The purpose of the *Hawai'i Water Conservation Plan, 2013*, is to identify and implement water use and delivery efficiency measures to conserve the fresh water resources of the state. The plan is intended to be a guiding document for the CWRM as they develop and implement water efficiency measures that can be implemented across the state by various water user groups.

Hawai'i Drought Plan

The purpose of the *Hawai'i Drought Plan, 2005 Update*, is to develop coordinated emergency response mechanisms and outline steps towards mitigating the effects of future drought occurrences. It provides a framework for integrating federal, State, County and private sector actions to reduce drought impacts. The Maui County Drought Committee participates in preparation of the County of Maui Drought Mitigation Strategy, which informs the County Multi-Hazard Mitigation Plan. The Maui Drought Committee is responsible for interfacing with agencies, stakeholders and the Hawai'i Drought Council, as well as monitoring ground water, stream/ditch water, and reservoir conditions and the local impacts of drought.

Climate Change Adaptation Priority Guidelines

In 2012 the Hawai'i State legislature amended the Hawai'i State Planning Act, Chapter 226 HRS, by adding *Climate Change Adaptation Priority Guidelines* (Appendix 6). The Guidelines are intended to provide near-term implementation options to increase resilience and reduce vulnerability to risks related to climate change and a statewide strategy over the long-term. Under the Hawai'i State Planning Act, priority guidelines shall take precedence when addressing areas of concern such as County decision making and allocation of resources, county general plans and development plans, as well as capital improvement project appropriations and land use decision making.

The Guidelines states that climate change patterns already being seen in Hawai'i along with the forecast for increasing population and water demand underscore the need for “adaptive capacity” defined by laws and policies that require water management to be: (1) forward-looking—focused on both crisis avoidance and mitigation; (2) flexible—able to adjust to changing needs and conditions; (3) integrated—able to address climate-related impacts that cut across political and geographical boundaries; and (4) iterative—utilizing a continuous loop of

monitoring, feedback and reevaluation. Potential adaptive tools that are not being implemented presently or are only partially implemented are provided in Appendix 6.

Hawai'i Fresh Water Initiative

The Hawai'i Fresh Water Initiative was launched in 2013 by the nonprofit Hawai'i Community Foundation to bring multiple, diverse parties including Hawai'i Fresh Water Council together to develop a forward-thinking and consensus-based strategy to increase water security for the Hawaiian Islands. The resulting report, *"A Blueprint for Action-Water Security for an Uncertain Future"* presents policy and decision makers with a state-wide goal of 100 mgd in additional fresh water capacity statewide and a set of solutions for adoption.²⁸ The report focuses on three aggressive water strategy areas and individual targets for the public and private to achieve by 2030:

- **Conservation:** Improve the efficiency of the total underground aquifer water use rate by 8% from 330 gpd (statewide average) to 305 gpd per person. Target: 40 mgd in increased water availability by 2030.
- **Recharge:** Increase Hawai'i's ability to capture rainwater in key aquifer sector areas by improving stormwater capture and nearly doubling the size of our actively protected watershed areas. Target: 30 mgd in increased water availability by 2030.
- **Reuse:** More than double the amount of wastewater currently being reused in the Islands to 50 mgd. Target: 30 mgd in increased water availability by 2030.

2.0 INTEGRATED PLANNING PROCESS

The CWRM Framework provides guidelines for applying an integrated resource planning process. Maui WUDP update adopts key components of this process, including definition of multiple planning objectives as a basis for criteria against which resource scenarios are evaluated, and strong community involvement. Alternative planning scenarios and resource strategies are presented that consider cost, benefits, social and environmental impacts. Integrated planning assumes that trade-offs among conflicting planning objectives are necessary. Informing decision-makers about legal, regulatory, or practical constraints and uncertainties are important in order to make difficult trade-offs. The components of this process is depicted in the figure below. It is noted that DHHL plans were also formulated through an interactive process as detailed in those plans.

²⁸ Hawai'i Community Foundation. 2015. *Hawai'i Fresh Water Initiative, A Blueprint for Action: Water Security for an Uncertain Future*, 2016 – 2018. <http://www.Hawaiicommunityfoundation.org/strengthening/fresh-water>

Figure 2-1 Integrated Planning Process



Community Interests

Water planning, management, development and use affects and is important to virtually all people, segments of the population, and ecological systems on Maui. There are also stakeholders, interests, entities and communities who's engagement, cooperation and support will be important to the success of the WUDP and there are ways to categorize them. Some of the stakeholders and interests that were engaged during the WUDP process include:

<p>Policy</p> <ul style="list-style-type: none"> • CWRM, State Department of Health • Maui County Council, Council Water Resources Committee, Board of Water Supply 	<p>Water Purposes / Needs</p> <ul style="list-style-type: none"> • Kuleana and Public Trust Doctrine uses • Holders of water rights, water use permits, reservations • Potable water users • Nonpotable water users
<p>Stakeholders and Target Interests</p> <ul style="list-style-type: none"> • Kuleana, Mokus, Native Hawaiian community and beneficiaries • Business community • Agricultural community • Environmental community • Development community • Water purveyors • Landowners • Public agencies 	<p>Supporting Interests</p> <ul style="list-style-type: none"> • Public agencies • Scientific and educational community • Partnerships, program managers, organizations • Funding sources • Citizen scientists, advocates, volunteers

Community Participation Program

The public process included the following major components:

- The MIP was formulated through a lengthy and intensive public process and adopted in 2012. The Directed Growth Plan involved development of a set of Guiding Land Use Principles derived from the Focus Maui Nui WalkStory and PlanStory public outreach events and community workshops, planning literature and technical studies, followed by an iterative and integrated planning process in formulating and reviewing the plan components.
- The 1990 WUDP update process commenced in 2004 focusing on the MDWS Central Maui and Upcountry districts, with community workshops and meetings, technical studies and policy board and CWRM input, culminating with adoption of the MDWS Central Maui District WUDP by the County Council; however, the CWRM declined to adopt this limited scope WUDP.
- A revised WUDP Project Description was submitted to and accepted by CWRM in 2012.
- Initial community meetings were held regionally in 2013/2014.
- Community meetings (12) were held regionally in 2016 in Central/South, West, Upcountry, and East Maui. The sets of meetings included Round 1 - Issue identification, Round 2 – Profiles, Objectives and Strategies, and Round 3 – Strategies to Address the Key Issues.
- Target interest group meetings were held in 2015/2016: Group of diverse interests (2), Aha Moku O Maui and regional moku (2), agricultural (1), realtors (1), and Kaupo community (1).
- Ka Pa'akai consultation process conducted in 2016 (in progress).
- WUDP Survey distributed at meetings and online in 2016.
- Communications plan implemented in 2015/2016.
- All materials placed online.
- Progress reports provided in 2015/2016 to the Board of Water Supply (2), the Council's Water Resources Committee (2), and CWRM (2).

3.0 MANAGEMENT FRAMEWORK

The WUDP is both a companion to and implementation component of the Maui Island Plan by allocating water to land use while protecting resources.

3.1 Issues and Concerns

The WUDP provides an opportunity to comprehensively plan for the management, development and use of our water resources consistent with the Statewide Framework, MIP and local planning objectives, as well as to tackle local issues, by articulating them, identifying solution and strategies, and working to resolve conflicts.

The WUDP is intended to allocate water to existing and planned land use. The MIP identifies the following challenges related to water systems:

- Native Hawaiian water rights must be incorporated into water planning.
- Lack of scientifically based interim flow standards which relate to water rights and public trust purposes and planning for surface-water resources.
- Future agricultural water use is uncertain.
- Comprehensive water resources planning and system control, while the County controls a relatively small percentage of the water on the island.
- MDWS budget constraints in the face of rising costs and infrastructure repair and replacement needs.
- Energy production and efficiency is a substantial component of MDWS costs.
- Private water systems and wells can undermine public systems or have the potential for contamination of water resources.

Many of the water system challenges identified in the MIP are specific to the MDWS water systems. The DHHL Water Policy addresses the need to ensure the availability of adequate, quality water to serve its beneficiaries and land uses. The WUDP addresses all water uses and users for which multiple issues were identified through the public process. Initial meetings with diverse community interests and stakeholders identified and provided feedback on key water issues not addressed in the MIP or through other venues.

During the community outreach process, tensions were identified involving water resource availability and management, diverse water uses and users, regionally based resources and uses, and water rights and priorities, among others. A synthesis of key issues for each region reflects these tensions:

East/Hāna: The impacts of water transport from East Maui streams on the ecosystem and public trust and other local uses. Relates to alternative ways to meet the future water needs of dependent regions.

West/Lahaina: Alternative ways to meet the future water needs of public trust and other local uses in the region given increased growth, climatic changes and potential decreased water supplies, while managing resources in a sustainable way.

Central/South: Alternative ways to meet the future water needs of all water uses and users in the region given increased growth especially in south Maui and reduced water transport from East Maui streams and Na Wai ‘Eha.

Upcountry: Alternative ways to provide reliable supply to the region including the potential for increased storage, given increased growth, climatic changes, and highly variable water supply in the face of reduced transport.

3.2 Values and Principles

While discussions during the WUDP community outreach process focused on water related issues and solutions, they also revealed aspects that Mauians value and treasure. The following overriding values are synthesized from input during the community outreach process.

‘Wai’ as a vital cultural and sustaining resource

Native Hawaiians and the Hawaiian culture value “wai” as a fundamental and necessary sacred element, and they continue to advocate for the rights to continuous flowing streams supported by healthy watersheds and nearshore environments.

Maui’s natural beauty, native ecology and cultural heritage

Mauians are proud to reside in one of the most beautiful and distinctive places in the world. They value protection of Maui’s native ecology as essential to preserving the island’s beauty and cultural history, including its agrarian roots which support open spaces, native Hawaiian culture, and local self-reliance and independence.

Sustainable water resources

Maui is blessed with abundant groundwater, streams and ocean resources to serve its diverse needs. The native Hawaiians’ mauka-to-makai ahupua'a management system safeguarded adequate stream flow necessary to sustain human settlements, cultural traditions and natural ecosystems from one generation to the next.

Abundant, high quality water for all needs

Mauians value the availability of high-quality water to support social and economic needs, as well as the aspirations of all people and cultures that reside here.

The following principles capture values and beliefs prominently expressed by the community during public meetings as well as derived from the General Plan and other policy documents.²⁹ The principles were used to guide preparation of the WUDP in process and content, and can be consulted as 'things to keep in mind' as we implement the Plan and tackle future challenges.

- Respect the Public Trust doctrine and State Water Code as a foundation for water planning. The Native Hawaiian ahupua'a system and cultural traditions can provide guidance on water stewardship.
- The 'water kuleana' of all Mauians creates responsibilities as well as rights. Be transparent and inclusive of all Mauians in all aspects of water planning and management.

²⁹ Many of the principles are stated in the Hawai'i Fresh Water Initiative's, "A Blueprint for Action, Water Security for an Uncertain Future, 2016-2018 which captures well the sentiments of the Maui community.

- Recognize the complexity and interconnectedness of the hydrologic cycle, groundwater and surface water systems. Use the 'precautionary principle' in water planning, recognizing this era of climate unpredictability.
- Water resource management demands comprehensive and integrated policies and solutions. Consider both island-wide and regional effects and solutions to issues important to Mauians. Water resource planning and solutions should support ecological, social and financial sustainability.
- Create an actionable plan that provides water supplies for our diverse water uses. The options for solving water resource and supply issues will decrease and costs will increase with each year of delay.

These can be summarized as follows. The WUDP and planning objectives encompass these tenets.

- Ecologically holistic and sustainable
- Based on ahupua'a management principles
- Legal, science and community-based
- Action-oriented

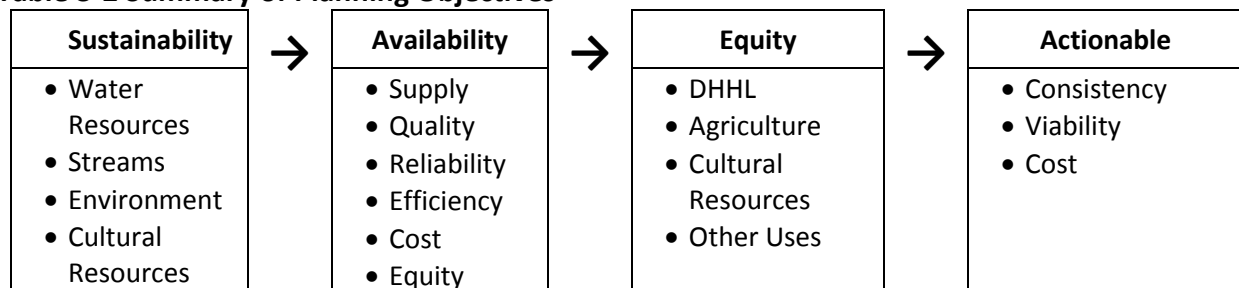
3.3 Planning Objectives

The Statewide Framework states that planning objectives form the basis of the evaluation of alternative resource strategies in the WUDP. The WUDP update process which commenced in 2004 and was originally focused on the MDWS Water System Districts generated a set of planning objectives based on input from the Water Advisory Committees through an iterative process. Suggestions for planning objectives were solicited, an extensive list of objectives, comments, policies and suggested resources was recorded, and these were sorted and grouped into a concise list of planning objectives.

Subsequently, in 2012 the scope of the WUDP update was broadened to include all water uses and users on Maui Island including cultural and environmental needs, and the planning objectives were again reviewed during community meetings held in 2012/13 and again during community, target interest, and policy board meetings in 2015/16. In order to measure the performance of resource options against the planning objectives, resource options and strategies are assessed and rated in terms of whether the strategy is likely to contribute positively or negatively to one or several planning objectives. A set of qualitative evaluation criteria or benchmarks are shown in the matrix below titled Planning Objectives Evaluation Criteria. A matrix with positive and negative ratings, indicated by “plus” or “minus” signs is provided in addition to a relative cost comparison and constraints that impact the viability of a specific resource or strategy, including legal constraints, practical constraints, and hydrologic constraints. *(The assessment of optional resources and strategies using these evaluation criteria is currently ongoing.)*

Table 3-1 Planning Objectives and Description

Planning Objective	Description
Sustainability	Maintain Sustainable Resources
Resources	Protect Water Resources
Streams	Protect and Restore Streams
Environment	Minimize Adverse Environmental Impacts
Equity	Manage Water Equitably
DHHL	Provide for Department of Hawaiian Homelands Needs
Agriculture	Provide for Agricultural Needs
Culture	Protect Cultural Resources
Availability	Provide Adequate Volume of Water Supply
Quality	Maximize Water Quality
Reliability	Maximize Reliability of Water Service
Efficiency	Maximize Efficiency of Water Use
Cost	Minimize Cost of Water Supply
Viability	Establish Viable Plans
Conformity	Maintain Consistency with General and Community Plans

Table 3-2 Summary of Planning Objectives

To ensure consistency with the MIP and community plans, the planning objectives derived through the WUDP public process were compared to the goals, objectives and policies in the General Plan, Maui Island Plan and Community Plans as shown in Appendix 2.

Table 3-3 Planning Objectives Evaluation Criteria

Criteria (Qualitative) Quantified Targets to be Developed as Applicable	Planning Objectives							
	Sustainability Resources Streams Environment	Agriculture	Equity DHHL Culture	Availability	Quality	Reliability	Efficiency Cost	Plan Viability Conformity
1. Groundwater sustainable yield levels are maintained over time	X			X				X
2. Stream flows restored to level to support stream ecosystems	X		X	X				X
3. Watersheds protected from invasive animals and plants	X			X				
4. Interim flow standards adopted for watersheds	X		X					
5. Scientific studies for aquifer systems complete (support science-based SY)	X							
6. Water resources and water system use is based on aquifer recharge and stream flows under drought conditions	X		X		X	X		
7. Chloride levels in wells remain stable (salt water intrusion)	X	X		X	X	X	X	
8. Use of recycled water increased	X			X		X		
9. Graywater and catchment systems installed	X			X				
10. Infrastructure projects increase recycled water use and stormwater capture	X			X				
11. Watershed collaboration increased	X			X				X
12. Native Hawaiian community consultation process instituted			X					X
13. Per capita water use decreased	X			X		X	X	
14. MDWS prioritize DHHL needs over lower priority needs			X					

Criteria (Qualitative) Quantified Targets to be Developed as Applicable	Planning Objectives							
	Sustainability Resources Streams Environment	Agriculture	Equity DHHL Culture	Availability	Quality	Reliability	Efficiency Cost	Plan Viability Conformity
15. Potable and irrigation systems water loss decreased	X			X			X	
16. Potable water use for nonpotable needs decreased	X							
17. Community water education increased	X						X	
18. Incentives for water conservation increased	X			X			X	
19. Drinking water standards met at all times				X	X	X		
20. Aquifer health maintained	X				X			
21. Public system water shortages to serve existing customers avoided				X		X		
22. Public water supply drought shortages avoided				X		X		
23. Contingencies in place to support water supply systems functions during emergency conditions				X		X		
24. Renewable energy use increased						X	X	
25. Water is available to timely serve development in MIP			X	X				X
26. Implementation plan for WUDP is incorporated into County budget and CIP planning						X		X
27. Strategies to meet all needs incorporated into WUDP			X					X

4.0 PLANNING SCENARIOS

The WUDP evaluates future water resources and demands for population growth and land use full build-out based scenarios as well as drought and climate change scenarios.

4.1 Population Growth Based Water Demand Scenario

The future growth scenario for the Maui Island WUDP is the Population Based Water Demand Scenario, based on the population growth rates for each community plan area in the Maui Island Plan from 2015 to 2035. The base year is 2014. Growth rates were updated in the updated Socio-Economic Forecast, July 2014, prepared by the Maui County Planning Department, Long Range Planning Division based on Maui County totals provided by Department of Business, Economic Development and Tourism. This takes into account all water sectors excluding large agricultural demands which are not correlated with population growth. High and Low Cases are generated based on the 2014 Socio-Economic Forecast. Projected agricultural water demand over the 20-year period is then added as a separate component for a comprehensive assessment of water demands.

4.2 Land Use Full Build-Out Based Water Demand Scenario

An alternative Land Use Based Scenario projects water demand based on full development of the County General Plan, County Zoning and DHHL land use plans over an undetermined period.

4.3 Planning for Uncertainty

Water resource protection, development and use planning entails making assumptions about existing conditions and future scenarios. Identifying uncertainties and assumptions provides an opportunity to plan for a practical range of contingencies. This section highlights the major uncertainties and contingencies of this WUDP, all of which are related to some degree.

Drought and Climate Change

Data and research suggest that Hawai'i should be prepared for a future with a warmer climate, diminishing rainfall, declining stream base flows, decreasing groundwater recharge and storage, and increased coastal groundwater salinity, among other impacts associated with drought. Reductions in native species will also continue to affect watersheds. Statistical modeling is being improved but uncertainty remains in drought forecasting.³⁰ The limitations of downscaling climate models for local impacts, uncertainty about natural climate and weather patterns, and uncertainty about relationships among factors, make regional and long-term predictions very complex.³¹ Conflicting or widely variable assessments of projected changes,

³⁰ WRPP, 2014 Draft, Section 8, Drought Planning

³¹ Climate Change Impacts in Hawai'i - A summary of climate change and its impacts to Hawai'i's ecosystems

along with long timescales affects the ability and urgency to incorporate specific actions into this WUDP. However, guidance in the *Climate Change Adaptation Priority Guidelines* and other efforts can be incorporated to increase resilience and reduce vulnerability to risks related to climate change.

Agricultural Water Demands

Predicting agricultural water demand is challenging due to uncertainty about the agricultural products market and regional crop water demand, the transition of lands used for sugarcane production to other crops, potential future agricultural use of kuleana lands, and associated legal issues relating to water rights and priorities of use. Regional crop types and locations, operational variables, and local climatic conditions also contribute to uncertainty.³² Scenarios presented rely on stated assumptions and the best data available.

5.0 PHYSICAL SETTING

Maui, the second largest island of the Hawaiian archipelago, encompasses about 727.2 square miles. The island of Maui was formed by two shield volcanoes. The older West Maui Volcano is known as West Maui Mountain and may be extinct, while the younger East Maui Volcano known as Haleakalā is considered dormant. The island has six aquifer sector areas and 112 surface water hydrologic units. The 2010 U.S. Census reported Maui County population to be 154,834 while Maui Island's population was 144,444 people, 93 percent of the total. The population of Maui County was estimated by the U.S. Census Bureau to be 163,019 in 2014, with Maui Island estimated to have about 157,087 persons in 2015. Population is projected to increase island-wide by 31.7 percent from 157,087 in 2015 to 206,884 in 2035, compared to a 33.5 percent increase from 2000 to 2015.

5.1 Climate

The topography of Maui and the location of the north Pacific anticyclone relative to the island affect its climate which is characterized by mild and uniform temperatures, seasonal variation in rainfall, and great geographic variation in rainfall. During the warmer dry season (May to September) persistent northeasterly trade winds blow 80 to 95 percent of the time. During the cooler rainy season (October to April), migratory weather systems often travel past the Hawaiian Islands, resulting in less persistent trade winds that blow 50 to 80 percent of the time. Low-pressure systems and associated southerly winds can bring heavy rains to the island, and the dry coastal areas receive most of their rainfall from these systems.

The variation in mean annual rainfall with altitude is extreme on Maui, with differences of more than 130 inches within one mile of Pu'u Kukui in the West Maui Mountains, where average

and communities, 2014

³² *Ko'olau Poko Watershed Management Plan*, Honolulu Board of Water Supply, 2012

annual rainfall exceeds 355 inches per year. In contrast, mean annual rainfall at the coast in the dry leeward areas is less than 15 inches. At higher altitudes, precipitation is a combination of rainfall and fog drip where the montane forest canopy intercepts cloud water. The fog zone on the leeward slopes of Haleakalā extends from about 3,900 to 5,900 feet, with an estimated thicker fog zone at altitudes of 2,000 to 6,560 feet along windward slopes.³³

Regular trade winds are key in generating rainfall which helps maintain Maui's water supply. However, a recent study showed that Hawai'i's trade winds have decreased in frequency by approximately thirty percent over the past 37 years, from 291 days per year in 1973 to 210 days per year in 2009.³⁴ The decrease in the trade winds could have serious implications for the Hawaiian Islands, including adversely impacting local agriculture, native ecosystems and endangered species, and the state's limited freshwater supply. Maui has experienced drought conditions in recent years. For example, based on the 1978–2007 monthly rainfall datasets, annual rainfall for the island was below average eight of the last 10 years (1998–2007).

5.2 Geology

Geology affects interactions between groundwater and surface water which may occur under the following conditions:

- High level water seeps into stream channels to provide base flow to streams
- Basal water in coastal areas flows into stream channels to provide base flow
- Stream water between marginal dike zones and coastal areas infiltrates into groundwater, as evidenced by losing stream reaches in these areas
- Basal water discharges through basal and/or caprock springs to provide water to wetlands and ponds

Basal occurrences of groundwater typically refer to a water table near sea level in high-permeability rocks. Groundwater in vertically extensive freshwater-lens systems can also be considered basal groundwater depending on the definition used.

West Maui Mountain and East Maui Volcano (Haleakalā) were built primarily by volcanic eruptions and layers of lava flows. The layers of lava flows were intruded in places by dikes, which consist of dense, low-permeability rock that formed when magma supplying lava flows solidified in narrow, near-vertical fissures below the ground surface. In the inland region of West Maui Mountain, near-vertical dikes radiating in all directions from the summit impound groundwater in compartments of volcanic rock in the caldera and permeable lava flows on the flanks. The water table of the dike-impounded groundwater systems in the West Maui Mountain interior may be more than 3,500 feet above sea level. Seaward of the dike-

³³ Gingerich, S.B., and Engott, J.A., 2012, Groundwater availability in the Lahaina District, west Maui, Hawaii: U.S. Geological Survey Scientific Investigations Report 2012–5010, 90 p.

³⁴ Garza, J.A., P.-S. Chu, C.W. Norton, and T.A. Schroeder (2012) Changes of the prevailing trade winds over the islands of Hawai'i and the North Pacific. *Journal of Geophysical Research*, 117, D11109, doi:10.1029/2011JD016888

impounded systems, freshwater-lens groundwater systems exist in the dike-free high-permeability volcanic rocks and sedimentary deposits.

A freshwater-lens system consists of a lens-shaped freshwater body, an intermediate brackish-water transition zone, and underlying saltwater. Water levels of groundwater bodies in the dike-free volcanic rocks of West Maui Mountain are typically less than a few tens of feet above sea level. Fresh groundwater within the freshwater-lens system generally flows in a seaward direction from inland areas of West Maui Mountain toward the coast. Wedges of low-permeability sedimentary material referred to as caprock impede the seaward flow of fresh groundwater in freshwater-lens systems along parts of the northeast and southwest flanks of West Maui Mountain. Wedges of caprock between West Maui Mountain and Haleakalā also impede the flow of fresh groundwater between West Maui Mountain and the isthmus.

On northeast Haleakalā, in the area between Makawao and Ke'anae Valley, fresh saturated groundwater occurs as perched, high-level water held up by relatively low-permeability geologic layers above an unsaturated zone, and a freshwater-lens system underlain by seawater. The perched groundwater is several tens of feet below the ground surface within layers of thick lava flows, ash, weathered clinker beds, and soils. Collectively, this assemblage of layers has low permeability that impedes the downward movement of the perched, high-level groundwater. An unsaturated zone and a freshwater-lens system are beneath the high-level groundwater. The freshwater-lens system is located within high-permeability basalt lava flows and has a water table that is several feet above sea level. In the area between Ke'anae Valley and Nāhiku, the groundwater system appears to be saturated above sea level to altitudes greater than 2,000 feet. For southeast and southwest Haleakalā, information related to groundwater systems remains sparse although perched and freshwater-lens systems are expected to be present.³⁵

5.3 Water Resources

The *State Water Resource Protection Plan* encourages effective ground and surface water management through the application of a hydrologic unit systems approach that focuses on the interaction and relationships between ground and surface water systems and water resource management. The hydrologic cycle describes the constant movement of water between the ocean, atmosphere, and Earth's surface, focused on precipitation, infiltration and recharge, runoff, and evapotranspiration. Agricultural and urban activities alter infiltration and runoff patterns, affecting the components of the hydrologic cycle.

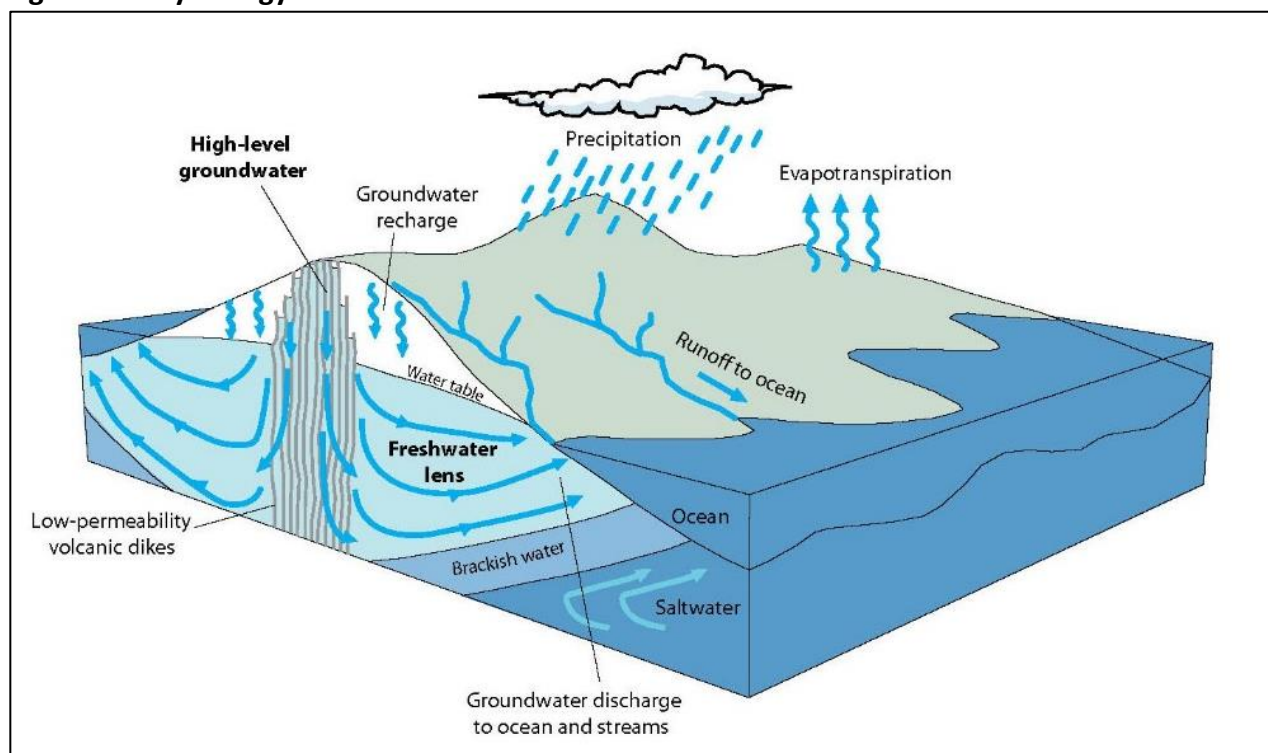
Hydrology

Hydrology is the scientific study of the occurrence, distribution, movement and properties of the waters of the earth and their relationship with the environment within each phase of the hydrologic cycle. The water cycle, or hydrologic cycle, is a continuous process by which water

³⁵ State Water Resources Protection Plan, 2008

moves from the earth's surface (including the oceans) to the atmosphere and back to the land and oceans.³⁶ Climate, hydrology, geology and human activities affect the water cycle and the interconnected surface and ground water systems. The figure below provides a generalized diagram of the hydrology of pacific islands.

Figure 5-1 Hydrology of Ocean Islands



Hydrology of Ocean Islands, USGS Pacific Islands Water Science Center

The State Water Code defines ground water as “any water found beneath the surface of the earth, whether in perched supply, dike-confined, flowing, or percolating in underground channels or streams, under artesian pressure or not, or otherwise.” There are four different types of ground water on Maui: 1) basal water floating on salt water; 2) dike confined water; 3) water perched on relatively impervious soil or rock formation; and 4) shallow ground water. The greatest ground water reservoir is the basal water table near sea level, which is a fresh water lens that “floats” on seawater. This phenomenon is known as the Ghyben-Herzberg principle. Due to the difference in specific gravity of sea water and fresh water, theoretically for every foot of fresh water above sea level 40 feet of fresh water extend below sea level to maintain the equilibrium. However, in actuality, there is a zone of mixture or transition from seawater to fresh water.³⁷

³⁶ The USGS Water Science School, <http://water.usgs.gov/edu/hydrology.html>, retrieved August 1, 2016

³⁷ State Water Resources Protection Plan, 2008

Groundwater Recharge

Groundwater recharge is the replenishment of fresh ground water and depends on many natural and human-related factors, such as precipitation, fog drip, irrigation, direct surface runoff, soil moisture storage, and evapotranspiration. An understanding of groundwater recharge informs water resource management. Under natural conditions, the aquifer is in a hydrologic balance such that the inflow of natural rainfall recharge equals the outflow or the coastal leakage, and the volume of aquifer storage remains constant. Hydraulic head, the water level as it relates to water pressure, affects the speed of water movement and the storage of an aquifer. The hydraulic head of a basal aquifer is highest at its inland boundary and gradually reduces toward the coastline. This spatial variation of the hydraulic head induces groundwater flow from mountain areas toward the ocean. However, forced draft or pumping has disrupted the natural balance of Hawai'i aquifers.³⁸ Groundwater storage depletion as a result of groundwater withdrawal, evidenced by lowered water tables and a rise in the bottom of the freshwater lens (transition zone), as well as diminished streamflow, is a potential limitation to groundwater availability.³⁹

The 2014 USGS study, *Spatially Distributed Groundwater Recharge Estimated Using a Water Budget Model for The Island of Maui, Hawai'i, 1978–2007*, concluded that the spatial distribution of rainfall is the primary factor determining spatially distributed recharge estimates for most areas on Maui. Estimated mean annual recharge on Maui is about 1,340 mgd for average climate conditions (1978–2007 rainfall and 2010 land cover).⁴⁰ Mean annual recharge of each of Maui's 25 aquifer system areas ranges from about 13 to 222 mgd for average climate conditions.⁴¹ About 60 percent of recharge islandwide occurs in the Ko'olau and Hāna aquifer sector areas. Precipitation (rainfall and fog interception) comprises most of inflow (precipitation, irrigation, septic leachate, and direct recharge); on average about 45 percent of precipitation is recharged.⁴² Irrigation in the Central aquifer sector area is substantial and constitutes about 43 percent of its total inflow.⁴³

The figure below shows the water budget components for each aquifer sector area based on the 2014 USGS Study. As the study indicates, more accurate estimation of the rate of natural recharge requires an improved understanding of precipitation, including fog drip and rainwater, surface runoff, and evapotranspiration.

³⁸ State Water Resources Protection Plan, 2008.

³⁹ Volcanic Aquifers of Hawai'i—Hydrogeology, Water Budgets, and Conceptual Models

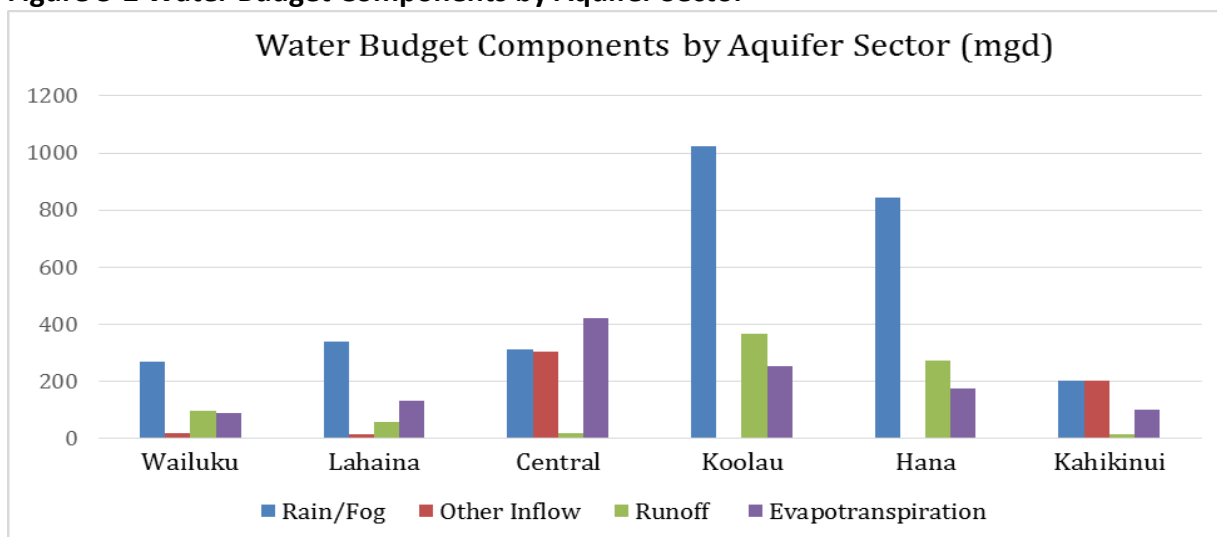
⁴⁰ Based on water budget area which more closely aligns with the 2008 WRPP average annual recharge is 1329 mgd.

⁴¹ Spatially Distributed Groundwater Recharge Estimated Using a Water-Budget Model for the Island of Maui, Hawai'i, 1978–2007, Table 8, Water Budget Area A and B.

⁴² Spatially Distributed Groundwater Recharge Estimated Using a Water-Budget Model for the Island of Maui, Hawai'i, 1978–2007

⁴³ Ibid, Table 8, Water Budget Area A.

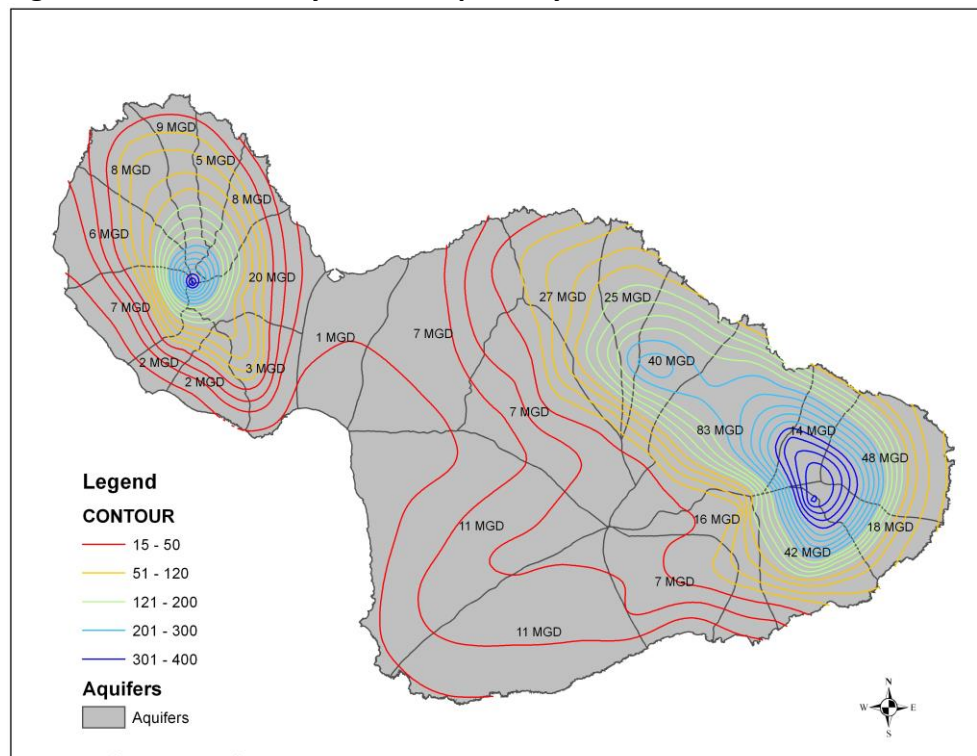
Figure 5-2 Water Budget Components by Aquifer Sector



MDWS Water Resources and Planning Division based on Spatially Distributed Groundwater Recharge Estimated Using A Water-Budget Model For The Island of Maui, Hawai'i, 1978–2007, Table 8, Water budget area A, Average climate conditions, 1978–2007 rainfall and 2010 land cover. (Groundwater Recharge.xlsx)

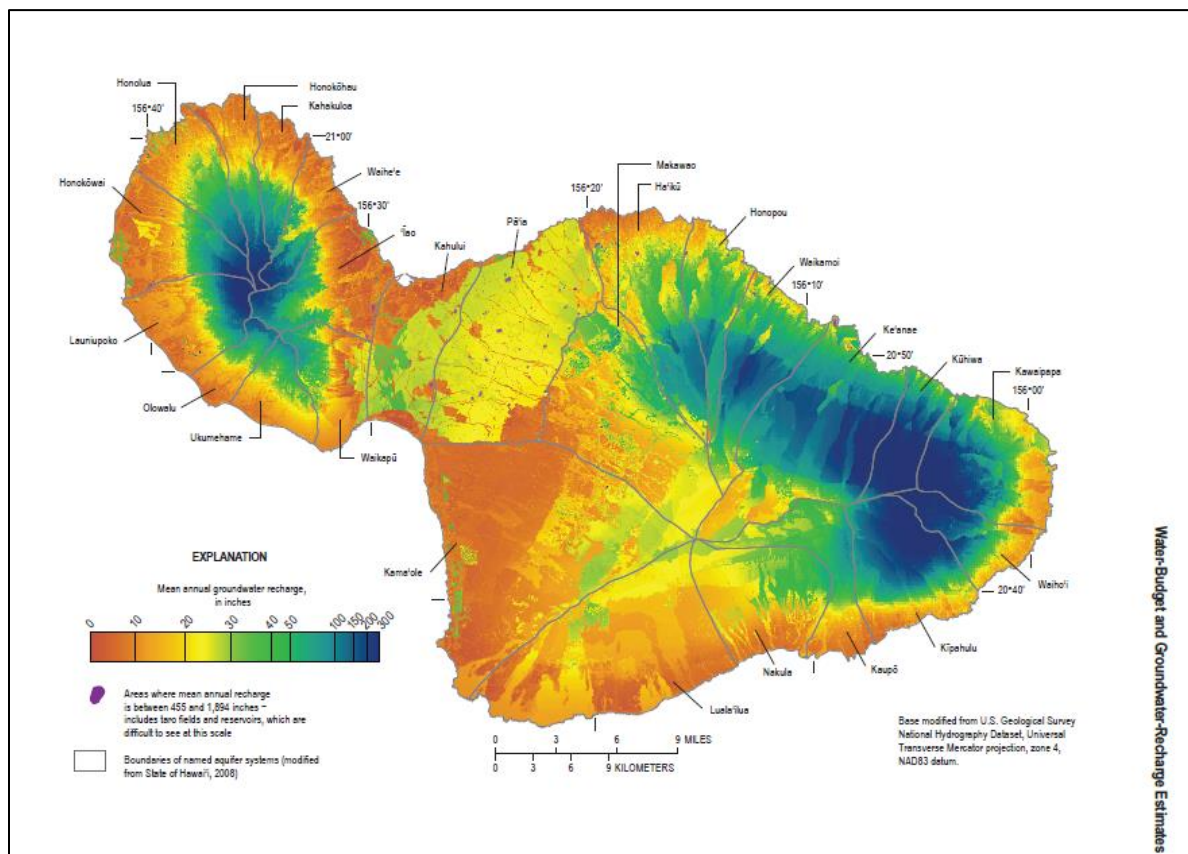
Figure 5-3 demonstrates a correlation between rainfall isohyets and sustainable yields. This is reflected in the distribution of mean annual groundwater recharge for average climate conditions in the subsequent figure.

Figure 5-3 Rainfall Isohyets and Aquifer System Sustainable Yields



2011 Rainfall Atlas of Hawai'i

Figure 5-4 Distribution of Mean Annual Groundwater Recharge for Average Climate Conditions

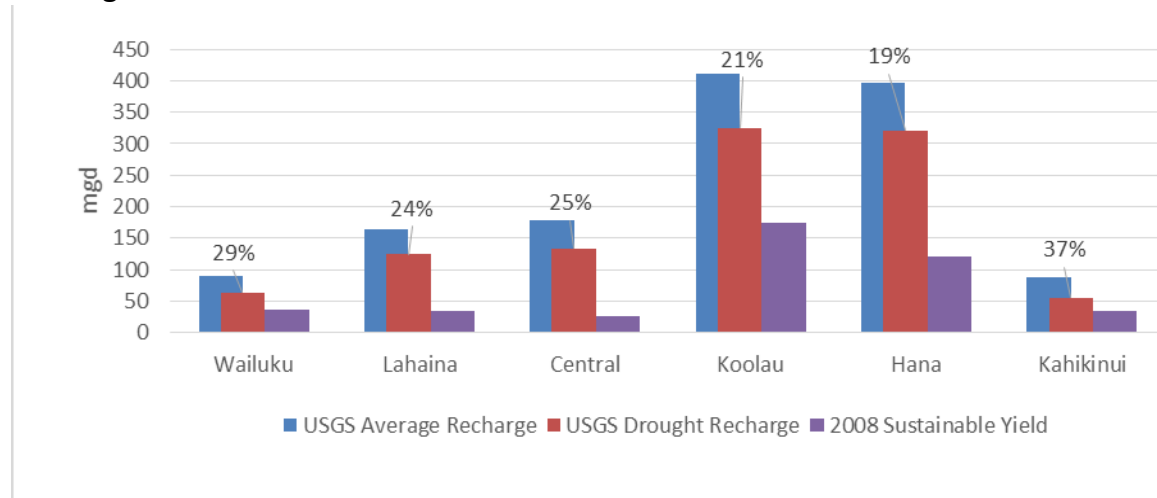


USGS, Spatially Distributed Groundwater Recharge Estimated Using a Water-Budget Model for the Island of Maui, Hawai'i, 1978–2007

Drought Effects

Drought is a persistent and extended period of below normal precipitation. Meteorological drought is usually an expression of the precipitation level's departure from normal over some period of time and can be an early indicator of drought. Agricultural drought occurs when soil moisture is inadequate to meet the needs of a particular crop at a particular time. Hydrological drought refers to deficiencies in surface and subsurface water supplies, reflected in declining surface and ground water levels. Due to lag time between a lack of rainfall and the observed decrease of water levels, hydrological drought will not be reflected until precipitation is deficient over an extended period of time. The drought from 1998 to 2003 had severe impacts throughout Hawai'i, including numerous wildland fires, record-low rainfall, and agricultural losses. Hawai'i has experienced D2 (severe) drought conditions somewhere in the state since June 2008 according to the U.S. Drought Monitor. The *Pacific Islands Regional Climate Assessment (2012)* reports an increase in average air temperature in the Hawaiian Islands from 1916-2006, and downward trend in rainfall across the state since the beginning of the 20th century and an even steeper decline since 1980 with the tendency for more prolonged dry periods, reduced stream base-flow, and a decrease in groundwater recharge and storage. A

Figure 5-6 Average Mean Recharge Under Average and Drought Climate Conditions, Percent Recharge Reduction and Sustainable Yield



USGS, Spatially Distributed Groundwater Recharge Estimated Using A Water-Budget Model For The Island of Maui, Hawai'i, Table 8. 2014; CWRM 2008 sustainable yield. USGS figures based on water-budget-area B (or A where there is no B), entire aquifer-system area, average climate. Average climate conditions are 1978–2007 rainfall and 2010 land cover. Drought conditions are 1998–2002 rainfall and 2010 land cover. (Groundwater recharge.xlsx)

In 2017, USGS discovered an error in data that affected published groundwater-recharge estimates for Maui and other islands. The recharge estimated for 1978 – 2007 rainfall and 2010 land-use conditions were revised and available on May 16, 2017 and are reflected in the table below. Recharge for drought conditions and associated reports and datasets were not available yet at the time of completing this WUDP draft. The percentage drought recharge reduction is assumed to not change significantly. The island wide impact in about a 2 percent decrease in recharge, with increases in certain aquifer systems and decreases in others, with a net decrease in all aquifer sectors except Wailuku. It is expected that the corrected data will be reflected in adjusted sustainable yield in CWRM's 2017 update to the Water Resources Protection Plan.

Table 5-1 - Average Climate and Drought Climate Conditions by Aquifer Sectors (mgd)

Aquifer Sector Area	2008 WRPP Average Recharge	May 2017 Corrected Recharge	USGS Average Recharge*	USGS Drought Recharge*	% Drought Recharge Reduction (USGS)
Wailuku	60	92	91	64	29%
Lahaina	73	162	163	125	24%
Central	59	175	179	134	25%
Ko'olau	397	404	411	325	21%
Hāna	245	379	397	322	19%
Kahikinui	78	85	88	56	37%
Maui Island	912	1297	1329	1025	23%

*USGS, Spatially Distributed Groundwater Recharge Estimated Using A Water-Budget Model For The Island of Maui, Hawai'i, 2014, Table 8. Report not yet reflecting corrected recharge numbers published 5/16/17

USGS figures based on water-budget-area A and water-budget-area B in Wailuku and Lahaina aquifer sectors, entire aquifer-system area, average climate. Average climate conditions are 1978–2007 rainfall and 2010 land cover. Drought conditions are 1998–2002 rainfall and 2010 land cover. WRPP- 1990, updated 2008 from CWRM where applicable, natural conditions are 1916–1983 mean rainfall and a uniform, unirrigated land cover. Scenario study areas may differ from the WRPP areas.

Sustainable Yield is determined by using recharge numbers determined over an extended time period which includes droughts. Sustainable yield is equal to a fraction of the recharge. In a basal lens the fraction is about half (0.46 percent) for Maui Island.⁴⁵ In high level aquifers about three-fourths of the recharge can be taken as sustainable yield.⁴⁶ During a drought, sustainable yield would not necessarily change, but rather Water Reduction Plans or Drought Plans would be consulted.⁴⁷ Water availability during a future drought is better assessed by looking at pumping history to evaluate how and where chloride concentrations affected water availability during past droughts. To evaluate future droughts under different conditions, such as different drought lengths and magnitude or other hydrologic changes, the best tool would be the groundwater model.⁴⁸ While not purported to represent a recalculation of the State's sustainable yield, substituting the reduced recharge in their RAM groundwater flow and transport model may provide rough estimate too. This is a straightforward, but simplistic approach, and may provide an estimate of where and how much pumping needs to be reallocated during a drought. Although hypothetical, the effect of a direct relationship between drought recharge reduction and sustainable yield is shown in the following table as a possible benchmark or baseline for groundwater resources during drought conditions.

Table 5-2 Illustrative Example of Drought Recharge Reduction on Sustainable Yield (mgd)

Aquifer Sector	2008 SY	Drought Recharge Reduction (%)	Reduced SY (Hypothetical, 100% Drought Recharge Reduction)*
Wailuku	36	29%	25
Lahaina	34	24%	26
Central	26	25%	19
Ko'olau	175	21%	139
Hāna	122	19%	99
Kahikinui	34	37%	21
Total	427		329

*% Drought Recharge Reduction: USGS, Spatially Distributed Groundwater Recharge Estimated Using A Water-Budget Model For The Island of Maui, Hawai'i, 2014, Table 8. Report not yet reflecting corrected recharge published 5/16/17

SY Reduction - assume SY is reduced by 100% of recharge. (Groundwater Recharge.xlsx)

⁴⁵ Robert Chenet, Geologist, CWRM, personal communication 12/1/2016.

⁴⁶ State Water Resources Protection Plan, 2008.

⁴⁷ Robert Chenet, Geologist, CWRM, personal communication 12/1/2016.

⁴⁸ [William R. Souza, Hydrologist, USGS Pacific Islands Water Science Center](#), personal communication 12/2/2016.

Climate Change Effects

Climate change patterns already being seen in Hawai'i are projected to become increasingly serious before the middle of the 21st century, including (a) declining rainfall, (b) reduced stream flow, (c) increasing temperature, and (d) rising sea level. Each poses serious consequences for the replenishment and sustainability of groundwater and surface water resources. These trends are further compounded by potential changes in the trade wind regime, the intensity and frequency of drought and storm events, the El Nino-Southern Oscillation, and the Pacific Decadal Oscillation.⁴⁹

The Pacific Regional Integrated Sciences and Assessments' (Pacific RISA) *Maui Groundwater Project* is an interdisciplinary research effort to inform decisions about the sustainability of groundwater resources on the island of Maui under future climate conditions. A new hydrologic model is being used to assess the impact of changing climate and land cover on groundwater recharge over the island. Preliminary future climate projections for Maui island include: 1) temperature increases at all elevations; 2) wet areas get wetter; 3) dry regions are mixed (some wetter, some drier); 4) mean annual rainfall increases; seasonal patterns show May-September drying in Central Maui; 5) Mean annual reference evapotranspiration increases; and 6) little change in cloud-base elevation and trade-wind inversion height.⁵⁰

The Hawaiian Islands Climate Synthesis Project which seeks to develop science-based syntheses of climate impacts and adaptation options for terrestrial and freshwater resources of the Hawaiian Islands indicates low or moderate confidence in predictions for most climate variables. Vulnerabilities and projected changes most relevant to water resource planning, some of which are already incrementally occurring on Maui, are summarized in the subsequent table.

Table 5-3 Climate Changes and Trends Relevant to Water Planning for Maui Island

Climate Variable	Trend	Relative Change by 2100	Confidence
Air Temperature	↑	High	High
Precipitation (amount and timing)	↑↓	Low to High	Low
Precipitation (extreme events)	↑↓	Low to Medium	Low
Drought	↑	Medium	Low
Streamflow	↓	Low to High	Low
Coastal flooding and saltwater intrusion	↑	High	Moderate
Species distribution (native and invasive plants)	↑↓	Medium to High	Moderate

⁴⁹ *Water Resources and Climate Change Adaptation in Hawai'i: Adaptive Tools in the Current Law and Policy Framework.*

⁵⁰ Pacific RISA. *Participatory Scenario Planning for Climate Change Adaption: Final Land Use Input*, Pacific RISA, November, 2014

Climate Variable	Trend	Relative Change by 2100	Confidence
Wildfire	↑	Unknown	Low

EcoAdapt. 2016. Climate Changes and Trends for Maui, Lānaʻi, and Kahoʻolawe. Prepared for the Hawaiian Islands Climate Synthesis Project, part of the Pacific Islands Climate Change Cooperative's Hawaiian Islands Terrestrial Adaptation Initiative.

Table 5-4 Projected Changes and Confidence Level for Climate Variables

Climate Variable	Projected Changed	Confidence (trend direction, magnitude)
Air Temperature	<i>Mean annual temperature</i> > By 2021---2050: increase of +1-2°F > By 2041---2070: increase of +1-3°F > By 2070---2100: increase of +2-5°F (up to +6.1-6.3°F in higher elevations, +3.6-4.5°F in lower elevations) <i>Heat waves</i> > Extreme heat days expected to become more frequent and more intense	High > High certainty that temperatures will increase > The amount of increase is somewhat uncertain due to climate model variables
Precipitation (amount and timing)	Multiple possibilities for precipitation differ in direction and magnitude of change: > Little to no change in precipitation by 2071-2099 (<i>Keener et al. 2013</i>) > Increased rainfall on windward slopes and decreased rainfall on leeward slopes by 2099 (Hamilton 2013) > Moderate to large decrease in precipitation (<i>Timm et al. 2015</i>): By 2041-2071: 16 to 18% (wet season), 24% to 32% (dry season) By 2071-2099: 17% to 25% (wet season), 29% to 46% (dry season)	Low > Precipitation highly variable depending on location > Studies disagree on direction and magnitude of change > Many variables affect climate models
Precipitation (extreme events)	<i>Extreme precipitation events</i> At least two possibilities differ in direction and magnitude of change > Reduced frequency of extreme precipitation events by 2100, with greater reductions in dry areas (<i>Timm et al. 2011</i>) > Little change in frequency (<i>Takahashi et al. 2011</i>) <i>El Niño events</i> (by 2090) > Slight decrease in number of El Niño events (versus 1891---1990) > Extreme El Niño events twice as likely to occur (from one event every 20 years to one event every 10 years) > No change in spatial pattern of El Niño events <i>Tropical cyclones</i> > Increased frequency and strength around the Hawaiian Islands	Low > Climate models disagree whether extreme events will become more or less frequent/severe, but most models predict a decrease in frequency and an increase in intensity > Changes may vary by location and the type of event
Drought	By 2080-2100:	Low

Climate Variable	Projected Changed	Confidence (trend direction, magnitude)
	<ul style="list-style-type: none"> > Increased risk in low- and mid-elevation leeward areas > Decreased risk on mid-elevation windward slopes of Haleakalā and summit of Mauna Kahalawai > No change in risk in other areas 	<ul style="list-style-type: none"> > Drought predictions are closely related to precipitation, which are very uncertain > Few studies have projected drought risk
Streamflow	<ul style="list-style-type: none"> > No streamflow projections are available for the coming century. Mean annual rainfall decreases within a watershed are likely to result in: > Decreased low flows and streamflow/ base flow declines > Flows would become more variable and more unstable ('flashy'), especially in wet years 	<p>Low</p> <ul style="list-style-type: none"> > Streamflow closely related to precipitation and temperature changes; also land cover, groundwater withdrawals, CO2 levels
Coastal flooding and saltwater intrusion	<ul style="list-style-type: none"> > Waiehu Deep Monitor Well (north Maui) 1985---1999, midpoint of transition zone between freshwater and sea water rose 2.2 m/year (i.e., freshwater lens became shallower) > Mahinahina Deep Monitor Well (west Maui) No change in midpoint of transition zone over time > No projections available for saltwater intrusion > Sea level rise will likely contribute to increased water salinity and higher water tables, especially during storms > Drought conditions increase groundwater salinity > Increased populations and water withdrawals will contribute to saltwater intrusion into groundwater sources 	<p>Moderate</p> <ul style="list-style-type: none"> > No downscaled sea level rise projections for this region > Saltwater intrusion is impacted by recharge rates and groundwater pumping/withdrawals (withdrawals likely play a larger role in saltwater intrusion than does sea level rise)
Species distribution (native and invasive plants)	<p><i>Native plant species</i></p> <ul style="list-style-type: none"> > Downslope contraction of cloud forest vegetation on Haleakalā if rainfall decreases > Upslope movements may be possible if rainfall increases, but habitat gains would be modest compared to the losses associated with drought <p><i>Native plant species (by 2100)</i></p> <ul style="list-style-type: none"> > 39% average reduction in climatically suitable habitat for native plants > 15% of modeled species will likely have no overlap between current and future suitable habitat > 5% of modeled species projected to lose >99% of their current climate envelope > Most vulnerable species include: single island endemics, species with a conservation listing <p><i>Invasive plant species (by 2100)</i></p> <ul style="list-style-type: none"> > ~11% increase in land area suitable for invasion 	<p>Moderate</p> <p><i>Native plant species</i></p> <ul style="list-style-type: none"> > Modeled changes in plant distribution dependent on multiple factors > El Niño events can significantly affect vegetation distribution by altering patterns of precipitation and drought, but projected changes in these factors are poorly understood <p><i>Invasive plant species</i></p> <ul style="list-style-type: none"> > Models may under-represent invasive species

Climate Variable	Projected Changed	Confidence (trend direction, magnitude)
	<ul style="list-style-type: none"> > Inhabitable habitat will increase greatly on the leeward slopes of Maui > Most modeled species are projected to expand > Invasion risk increases at higher elevation locations 	<ul style="list-style-type: none"> distribution > Climatic tolerances of species reaction to changes not well understood
Wildfire	<ul style="list-style-type: none"> > No wildfire projections available > Wildfire will likely increase if drought events increase 	<p>Low</p> <ul style="list-style-type: none"> > Wildfire strongly correlated with dry conditions; precipitation projections highly uncertain > Increasing temperatures likely to increase ET; may cause higher climatic water deficits even if precipitation increases slightly

Summarized from EcoAdapt. 2016. Climate Changes and Trends for Maui, Lāna'i, and Kaho'olawe. Prepared for the Hawaiian Islands Climate Synthesis Project.

Saltwater intrusion, the reduction of discharge to streams and the ocean, and lowering of water levels limit ground water availability. When water is withdrawn from a freshwater lens, the freshwater lens shrinks and saltwater or brackish water will intrude upward and landward into parts of the aquifer that formerly contained freshwater. The degree of saltwater intrusion depends on several factors, which include the hydraulic properties of the rocks, recharge rate, pumping rate, and well location. The effect of intrusion on a particular well depends on the vertical and lateral distance between the well and the transition zone. Wells completed in the freshwater lens near the coast are particularly likely to induce brackish water or saltwater movement into the well as pumping continues. Saltwater-water intrusion can be controlled by appropriately locating wells and controlling withdrawal rates. Groundwater withdrawal ultimately reduces the amount of discharge to springs, streams or the ocean; reduced flow can also lower water levels around the pumped well.⁵¹ During an extended drought source water quality can be affected by sea water intrusion or upconing brackish water.⁵²

Sea level rise and the associated coastal impacts have the potential to harm an array of infrastructure and environments including low lying coastal roads, water supply and wastewater systems. The University of Hawai'i Coastal Geology Group has predicted that conservatively sea level may rise up to one meter by 2100 affecting all coastlines and most

⁵¹ Gingerich, S.B. and Oki, D.S., 2000, Ground Water in Hawai'i: U.S. Geological Survey, Fact Sheet 126-00

⁵² Spatially Distributed Groundwater Recharge Estimated Using a Water-Budget Model for the Island of Maui, Hawai'i, 1978–2007

severely affecting Ma`alaea, North Kihei, Lahaina, Ka`anapali, and Kahului.⁵³ In many cases these impacts will stress an already ailing infrastructure. Water supply faces threats from both rising groundwater and saltwater intrusion in wells, as well as declining quality and quantity due to drought and downward trends in groundwater base flows. After considering climate change impacts and projected water demand increase, it is clear that careful water planning, stewardship, and climate adaptation are required.⁵⁴

Surface Water Hydrology

Streamflow consists of “(1) direct runoff of rainfall, in the form of overland flow and subsurface storm flow that rapidly returns infiltrated water to the stream, (2) ground-water discharge, in the form of base flow, where the stream intersects the water table, (3) water returned from bank storage, (4) rain that falls directly on streams, and (5) any additional water, including excess irrigation water, discharged to the stream by humans.”⁵⁵ The *Hawai'i Stream Assessment, 1990* lists 90 perennial streams on the island of Maui, which include streams flowing year-round and those which flow intermittently at lower elevations.⁵⁶ This information is now compiled as part of the *Atlas of Hawaiian Watersheds and Their Aquatic Resources* which is based on information in the Division of Aquatic Resources Aquatic Surveys Database.⁵⁷

Streams on Maui generally originate in the wet uplands of Mount Kahalawai and Haleakalā and flow toward the coast. The upper reaches of some streams on Mount Kahalawai flow perennially and are fed by persistent rainfall and groundwater discharging from dike-impounded water bodies. During dry-weather conditions, lower reaches of some streams have reduced or no streamflow as a result of water captured by diversion systems and water infiltrating the subsurface where the water table is at a lower elevation than the streamflow level. Losing stream conditions can also occur where withdrawals at a well lowers the local water table and attracts the stream water towards the pumping well. Streams on windward Haleakalā are fed by abundant rainfall and groundwater discharge. In the area between Makawao and Ke'anae Valley, groundwater discharges to streams from a perched, high-level saturated groundwater system. East of Ke'anae Valley, groundwater discharges to streams from a vertically extensive freshwater-lens system. Water is diverted from many streams on windward Haleakalā and is mainly used to irrigate sugarcane in the isthmus. Stream reaches on leeward Haleakalā tend to be ephemeral.⁵⁸ The downward trend in rainfall across Hawai'i and

⁵³ Maui County Countywide Policy Plan, p 14.

⁵⁴ Water Resources and Climate Change Adaptation in Hawai'i: Adaptive Tools in the Current Law and Policy Framework

⁵⁵ Oki, D.S., 2003, Surface Water in Hawai'i: U.S. Geological Survey Fact Sheet 045-03, p. 6.

⁵⁶ Hawai'i Stream Assessment, Report R84, December 1990.

http://files.Hawaii.gov/dlnr/cwrm/publishedreports/R84_HSA.pdf

⁵⁷ Division of Aquatic Resources Aquatic Surveys Database

http://www.Hawaii.gov/dlnr/dar/streams/stream_data.htm

⁵⁸ Spatially Distributed Groundwater Recharge Estimated Using a Water-Budget Model for the Island of Maui, Hawai'i, 1978–2007

on Maui since the beginning of the 20th century with steeper declines since 1980 has resulted in reduced base streamflow.⁵⁹

Transfer of water between hydrologic units occurs in most sectors on Maui. An example is the East Maui Irrigation (EMI) System which transports surface water along 74 miles of aqueduct and tunnel system from the Ko'olau sector to the dry Central sector for sugarcane irrigation. Irrigation creates an artificial relationship between Pa'ia and Kahului aquifers and the surface water from Ko'olau. There are cases where pumping wells located near streams have been determined not to affect proximal streamflow, such as when the streambed is higher than the ground water table. For example, wells (e.g. Mokuhaui wells) in Wailuku which pump ground water from 10 feet above sea level do not impact the nearby 'Iao Stream, which is located several hundred feet above sea level. A similar condition exists with the North Waihe'e Wells located in the neighboring Waihe'e Aquifer System Area where water levels are approximately eight feet above sea level and the Waihe'e River streambed invert elevation is much higher.

5.4 Groundwater Availability

Ground water is the primary source of supply for the majority of water users on the island served by both county-owned and private public water systems. The WUDP uses hydrologic units designated by CWRM for presentation of data and analysis, along with the master water resources inventory in the State Water Resources Protection Plan (WRPP). Maui Island is divided into six regions called Aquifer Sector Areas that reflect broad hydrogeological similarities while maintaining hydrographic, topographic and historical boundaries where possible. Aquifer Sector Areas are divided into Aquifer System Areas based on hydraulic continuity and related characteristics. Because these delineations are based largely on observable surface conditions and only limited subsurface information, boundary lines should be recognized as management lines and not as hydrologic boundaries.

Sustainable Yield

Ground water is replenished by rainfall recharge and classified as a renewable resource. The amount of ground water that can be developed is limited by the amount of natural recharge. However, because some aquifer outflow or leakage must be maintained to prevent seawater intrusion or some perennial streamflow, the sustainable yield of an aquifer normally represents a percentage of the natural recharge. The CWRM has adopted sustainable yields for each aquifer system area to protect ground water resources and regulate water use by water use permits. Sustainable yield is defined as “the maximum rate at which water may be withdrawn from a water source without impairing the utility or quality of the water source as determined by the commission.” (HRS §174C-3)⁶⁰ It is the legal limit for withdrawals from any individual

⁵⁹ Water Resources Protection Plan Update, 2014.

<http://files.Hawaii.gov/dlnr/cwrmp/planing/wrpp2014update/WRPP-2014Ch8SummaryDroughtPlanning.pdf>

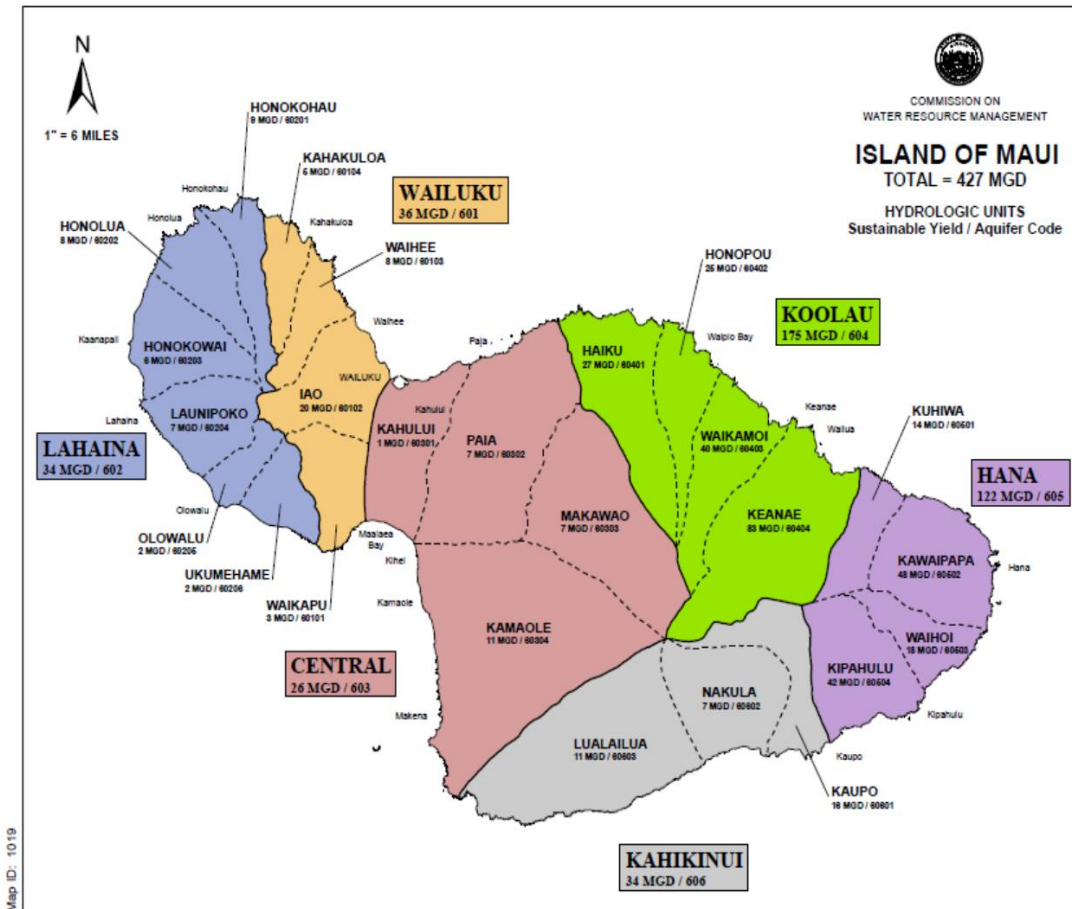
⁶⁰ Sustainable yield refers to the forced withdrawal rate of groundwater that could be sustained indefinitely without affecting either the quality of the pumped water or the volume rate of pumping. It depends upon the head

aquifer. In setting sustainable yield, the CWRM assesses the quantity of groundwater recharge to the aquifer as well as the rights of ground and surface water users and groundwater dependent ecosystems.

Sustainable yield changes over time due to climatological trends, rates of recharge, interaction between stream flow and groundwater, land use and other factors. Insufficient hydrologic, geologic and meteorological data require the estimation of critical input parameters in sustainable yield models. As new and better data becomes available, the CWRM must periodically review and refine sustainable yield estimates. The United States Geological Survey (USGS) in particular continues to conduct scientific studies of groundwater recharge and availability on Maui which may support revised sustainable yield estimates in the future as indicated on its website at <http://hi.water.usgs.gov/publications/pubsmaui.html>. Due to variables and inherent uncertainty in each prediction, CWRM applied the “precautionary principle” in adopting sustainable yields in the 2008 WRPP. The WUDP uses the established sustainable yield for an aquifer system as the basis for resource evaluation. However, sustainable yields estimates are to be used as a planning guide rather than as an absolute constraint. Sustainable yield is under review as part of the 2016 -2017 WRPP update.

Figure 5-7 Groundwater Hydrologic Units, Aquifer Codes and Sustainable Yields

selected as the minimum allowable during continuous pumping. Head is the elevation [or height] of the unconfined water table above sea level. There is not a unique value for sustainable yield; the value depends on the head that will preserve the integrity of the groundwater resource at the level decided upon by the manager. Sustainable yield is equal to a fraction of the recharge. In a basal lens the fraction is usually more than half and sometimes greater than three fourths where initial heads are high. In high level aquifers about three fourths of the recharge can be taken as sustainable yield. State Water Resources Protection Plan, 2008.



As shown in the table below, the lowest predicted sustainable yield for each aquifer system area was selected as the 2008 sustainable yield, with exceptions to this rule for 'Iao and Waihe'e Aquifer Systems. The sustainable yield for the 'Iao Aquifer was maintained mid-range at 20 mgd as this is believed to be the best estimate to date based on numerical models, deep monitor well data, and historical pumpage records. For the Waihe'e Aquifer, the CWRM elected to maintain the sustainable yield at 8 mgd based on (1) current groundwater demands within the system, (2) 8 mgd falls within the predicted range of sustainable yields for the aquifer system area, (3) the presence of a deep monitor well within the system that will allow for long-term monitoring of the transition zone, and (4) groundwater studies support 8 mgd as a safe yield. Sustainable yield ignores significant importation of surface water into Kahului and Pa'ia Aquifer System Areas, which supports the ability to withdraw fresh water from the basal aquifer at significantly higher rates than the sustainable yield without apparent negative impacts (i.e. rising chloride concentrations or decreasing water levels).⁶¹

The table below shows the 2008 sustainable yield, range and degree of confidence the CWRM places on the number, ranging from (1) most confident to (3) least confident directly related to the type, quality, and quantity of hydrologic data used in the sustainable yield determination.

⁶¹ State Water Resources Protection Plan, 2008.

Table 5-5 Maui Island Aquifers Sustainable Yields, 2008

Aquifer Sector/System	Aquifer Code	Sustainable Yield Range (mgd)	Sustainable Yield (mgd)	Confidence Ranking
Wailuku	601		36	
Waikapu	60101	3-6	3	2
'Iao	60102	11-31	20	1
Waihe'e	60103	6-15	8	2
Kahakuloa	60104	5-8	5	2
Lahaina	602		34	
Honokohau	60201	9-17	9	2
Honolua	60202	8-10	8	2
Honokowai	60203	6-11	6	2
Launiupoko	60204	7-14	7	2
Olowalu	60205	2-7	2	2
Ukumehame	60206	2-6	2	2
Central	603		26	
Kahului	60301	1	1*	2
Pa'ia	60302	7-8	7*	2
Makawao	60303	7-20	7*	3
Kamaole	60304	11-16	11	3
Ko'olau	604		174	
Ha'iku	60401	27	27	2
Honopou	60402	25-26	25	3
Waikamoi	60403	40	40	3
Ke'anae	60404	83	83	3
Hāna	605		122	
Kuhiwa	60501	14	14	3
Kawaipapa	60502	48	48	3
Waihoi	60503	18-21	18	3
Kipahulu	60504	42	42	3
Kahikinui	606		34	
Kaupo	60601	16	16	3
Nakula	60602	7	7	3
Lualailua	60603	11	11	3

Source: Hawai'i Water Resource Protection Plan, June 2008, Tables 3-10 and 3-11

* Only basal water

Groundwater Management Areas

The CWRM may designate an area as a water management area and limit the total quantity of water that can be withdrawn when the water resources of an area are determined to be

threatened by existing or proposed withdrawals of water, and subject future withdrawals to water use permit allocations. The State Water Code provides eight criteria for CWRM to consider in designating a ground water management area, including the following:

- Whether an increase in water use or authorized planned use may cause the maximum rate of withdrawal from the ground water source to reach 90 percent of the sustainable yield of the proposed ground water management area;
- There is an actual or threatened water quality degradation as determined by the department of health;
- Whether regulation is necessary to preserve the diminishing ground water supply for future needs, as evidenced by excessively declining ground water levels;
- Whether the rates, times, spatial patterns, or depths of existing withdrawals of ground water are endangering the stability or optimum development of the groundwater body due to upconing or encroachment of salt water;
- Whether the chloride contents of existing wells are increasing to levels which materially reduce the value of their existing uses;
- Whether excessive preventable waste of ground water is occurring;
- Serious disputes respecting the use of ground water resources are occurring; or
- Whether water development projects that have received any federal, state, or county approval.

The 90 percent of sustainable yield provides a regulatory buffer between SY and proposed withdrawals. The CWRM designated 'lao Aquifer System Area as a Groundwater Management area effective July 21, 2003, requiring water use permits for all non-individual domestic ground water uses.⁶² Water use permits issued as of August 2016 totaled 19.089 mgd with 0.911 mgd unallocated. The table in section 8.2.1 shows the sustainable yields adopted in 2008 by CWRM, 2014 pumpage, water use permits in groundwater management areas and pump capacity in other areas.

Developable Yield

Sustainable yield estimates adopted by the CWRM do not take into consideration a variety of factors that affect groundwater development. The sustainable yields provide an estimate for the entire aquifer system area assuming a single homogeneous geologic formation. The sustainable yield of basal aquifers represents the maximum aquifer pumping rate assuming optimal placement of wells and pump sizes. Groundwater may interact with streams due to dike influences and therefore availability may be subject to amendments of the interim IFS. Development cost and risk also reduce the potential for full development of an aquifer system area.⁶³ While the sustainable yields adopted by the CWRM are conservative, input received

⁶² State Water Resources Protection Plan. 2008

⁶³ Use of the term developable yield here differs from the concept of “developable yield” used by CWRM in the limited context of a one-to-one relationship with stream flow (water taken from a source, usually high-level but possibly basal intersecting a stream) which reduced groundwater feeding a stream by an equal amount.

from some community interests advocated an additional buffer to reflect these issues, especially where confidence ranking is low due to lack of hydrologic data.

5.5 Groundwater Quality

Groundwater is of high quality and is generally more reliable and less expensive to treat than surface water. The *Hawai'i Source Water Assessment Program (SWAP) Report* completed for Maui in 2004 assesses public drinking water sources for Potential Contaminating Activities (PCAs) to ground, surface and groundwater under the direct influence of surface water sources. The assessment delineates the area around a drinking water source through which contaminants may travel to the drinking water supply, inventories activities that may lead to the release of contaminants within the delineated area, and computes a susceptibility to contamination score for each drinking water source. This information supports the County's proposed wellhead protection ordinance which would impose land use regulations on high risk activities within wellhead capture zones.

The DOH Safe Drinking Water Branch's online Groundwater Contamination Viewer identifies detections of organic contaminants (which are generally a measure of human activity) detected by DOH and other reporting agencies and confirmed through repeat testing in drinking water wells, select non-potable wells and fresh water springs prior to treatment. Some contaminated wells may not be listed due to lack of reporting or testing, sources previously reported as contaminated whose latest test resulted in a "not detected" or "ND" report are no longer included, and some data are extremely old due to inability to retest. Detections on the Viewer in the figure below are identified within the Honokowai, Honolua, Kahului, Pa'ia and Ha'iku aquifer system areas are typically caused by herbicide applications including 1,2-Dibromo-3-Chloropropane (DBCP); Ethylene Dibromide (EDB); Atrazine and/or 1,2,3-Trichloropropane (TCP).

Figure 5-8 Groundwater Contamination Viewer Map for Maui Island



Groundwater Contamination Viewer, 09-23-2015, <https://Eha-cloud.doh.Hawaii'i.gov>

Changes in chloride concentration of pumped water over time can be a function of the pumping rate of a particular well, pumping at nearby wells, depth of the well, and recharge to the aquifer. Therefore, the evaluation of aquifer conditions based on chloride-concentration trends from the pumped wells has limitations.

The CWRM, USGS and others maintain or monitor deep monitoring wells which penetrate the freshwater basal aquifer into the underlying brackish and salt water and is used to estimate the thickness of the freshwater lens and the freshwater-saltwater transition zone. The CWRM monitors four deep monitoring wells on Maui: at Mahinahina Deep Monitor Well in the Honokowai Aquifer System Area near Lahaina, the Waiehu Deep Monitor Well and the 'Iao Deep Monitoring Well in the 'Iao Aquifer System Area, which is heavily pumped and may be showing signs of over pumpage, and the new Waihe'e Deep Monitor Well, located in the Waihe'e Aquifer System Area, which is hydraulically connected to the 'Iao Aquifer System Area.⁶⁴

⁶⁴ CWRM Monitoring Data, http://files.hawaii.gov/dlnr/cwr/monitoringdata/dmw_infos.pdf, August 2, 2016.

5.6 Surface Water Availability

There are 90 perennial streams in Maui, 82 of which have been diverted to some extent (Appendix 4). Streams provide riparian and instream habitats for many unique native species, support traditional and customary Hawaiian gathering rights and taro cultivation, provide recreational and aesthetic enjoyment, and affect the physical and chemical quality of receiving waters such as estuaries, bays, and nearshore waters.⁶⁵ Water from streams supplies a small proportion of drinking water island-wide but is a significant source of supply in West Maui and Upcountry.

The availability of surface water is uncertain due to multiple factors such as information about surface water resources and the effects of diversions on the ecosystem, as well as lack of numerical instream flow standards and legal issues. The main issues related to surface water in Hawai'i are: (1) streamflow availability; (2) the reduction of streamflow by surface diversions and, in some areas, ground-water withdrawals; (3) floods; (4) water-quality changes caused by human activities; and (5) erosion and sediment transport. The use of surface water in Hawai'i by agricultural and municipal water users and streamflow reduction caused by diversions often conflicts with traditional Hawaiian practices (taro cultivation and gathering of stream fauna), stream ecology, water quality, recreational activities, and aesthetics.⁶⁶

The drainage areas of surface water that are confined by topographic divides are generally referred to as watersheds. Surface water hydrologic units have been established by CWRM to provide a consistent basis for managing surface water resources. The watershed boundaries and hydrologic unit codes for Maui Island are shown in the figure below. While the WUDP is organized based on aquifer sector areas, surface water hydrologic units are referenced as relevant for watershed management, analysis of water transfers and resource use.

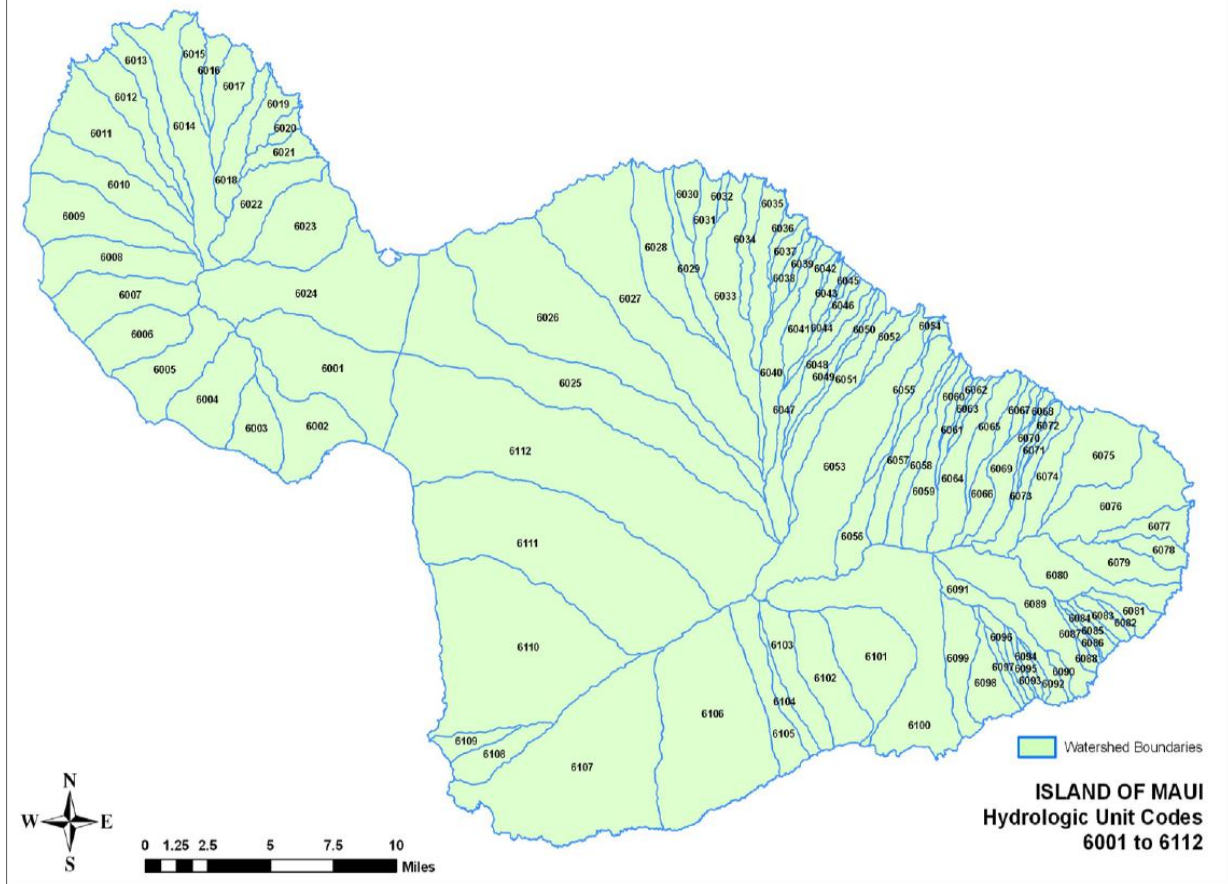
An inventory of streams on Maui is provided in Appendix 4.

Figure 5–9 Surface Water Hydrologic Units

⁶⁵ Cheng, C.L., 2016, Low-flow characteristics for streams on the Islands of Kaua'i, O'ahu, Moloka'i, Maui, and Hawai'i, State of Hawai'i: U.S. Geological Survey Scientific Investigations Report 2016-5103, 36 p. <http://dx.doi.org/10.3133/sir20165103>

⁶⁶ Surface Water in Hawai'i: U.S. Geological Survey Fact Sheet 045-03, Oki, D.S., 2003

**Commission on Water Resource Management
Surface-Water Hydrologic Units**



Instream Flow Standards

In accordance with the Water Code, the CWRM establishes and administers instream flow standards on a stream-by-stream basis as necessary to protect the public interest. Instream flow standard is defined as, “a quantity or flow of water or depth of water which is required to be present at a specific location in a stream system at certain specified times of the year to protect fishery, wildlife, recreational, aesthetic, scenic, and other beneficial instream uses.”

Section 174C-3, Hawai‘i Revised Statutes, defines instream use as “beneficial uses of stream water for significant purposes which are located in the stream and which are achieved by leaving the water in the stream”. Instream uses include, but are not limited to:

- (1) Maintenance of fish and wildlife habitats;
- (2) Outdoor recreational activities;
- (3) Maintenance of ecosystems such as estuaries, wetlands, and stream vegetation;
- (4) Aesthetic values such as waterfalls and scenic waterways;
- (5) Navigation;
- (6) Instream hydropower generation;

- (7) Maintenance of water quality;
- (8) The conveyance of irrigation and domestic water supplies to downstream points of diversion; and
- (9) The protection of traditional and customary Hawaiian rights.”

The CWRM’s mandate is to establish instream flow standards that will protect instream uses while allowing for reasonable and beneficial offstream use.

Interim instream flow standards (IIFS) were adopted for both East and West Maui streams in 1988 (Sections 13-169-44 and 48, Hawai‘i Administrative Rules). According to Section 13-169-46, Hawai‘i Administrative Rules, “Interim Instream Flow Standard for all streams on Hawai‘i, as adopted by the commission on water resource management on June 15, 1988, shall be that amount of water flowing in each stream on the effective date of this standard, and as that flow may naturally vary throughout the year and from year to year without further amounts of water being diverted offstream through new or expanded diversions, and under the stream conditions existing on the effective date of the standard, except as may be modified [by the commission].” Therefore, the IIFS are not based on scientific information but continue the “status quo” by setting the standard at the amount of water that was flowing in each stream on the date of adoption. For areas where measurable standards are not set, the CWRM basically regulates according to the users of surface water and ground water which were required to register their uses with CWRM when the State Water Code was enacted. Any new diversions (unless deemed de minimus, or too small to measure) require an amendment to the IIFS. CWRM is currently drafting an Instream Flow Program Implementation Plan which will, among other actions, develop a standardized IIFS methodology and set scientifically-based IIFS statewide. These standards will influence long-range planning instream and offstream uses.⁶⁷

Instream flow standards need to consider the best available information in assessing the range of present or potential instream and non-instream uses. Surface-water resources in an area must be quantified based on accurate long-term data before streamflow availability can be evaluated for existing and proposed uses. Balancing offstream and instream uses by the CWRM requires information on existing and future water use and quantified information on surface water availability, particularly natural flow during low-flow conditions, which has not always been available to set instream flow standards, support decision making and resolve litigation over rights to water between diverters and those desiring sufficient flow for instream uses as discussed below. The availability of streamflow during low-flow conditions is important to protect native stream animals, protect water quality and determine the total maximum daily load to characterize impaired waters, and to identify areas of groundwater discharge and assess the potential effect of groundwater withdrawal.⁶⁸

⁶⁷ Maui Island Plan, Chapter 6 Infrastructure and Public Facilities

⁶⁸ Cheng, C.L., 2016, Low-flow characteristics for streams on the Islands of Kaua‘i, O‘ahu, Moloka‘i, Maui, and Hawai‘i, State of Hawai‘i: U.S. Geological Survey Scientific Investigations Report 2016-5103, 36 p.
<http://dx.doi.org/10.3133/sir20165103>

The annual mean "Qp" flow is the daily average flow equaled or exceeded "p" percent of the time during the year. Q₅₀ is the median or natural base flow for a particular stream segment during a specified period. Base flow is dependent on groundwater discharge while total flow reflects base flow and rainfall runoff.⁶⁹ The base flow is a general guideline for the minimal amount of streamflow needed for fish habitat.⁷⁰ For perennial streams, the estimated long-term average base flow is 60 to 80 percent and thus 70 percent is used (Q₇₀). Flow exceeded 90% of time (Q₉₀ flow) is commonly used to characterize low flows and flow exceeded 95 percent of the time Q₉₅ represents extreme low-flow conditions.⁷¹ The report, *Low-flow characteristics for streams on the Islands of Kaua'i, O'ahu, Moloka'i, Maui, and Hawai'i, State of Hawai'i: U.S. Geological Survey Scientific Investigations Report 2016-5103*, estimates natural streamflow under low-flow conditions using statistical models, where low-flow conditions are flow-duration discharges that are equaled or exceeded between 50 and 95 percent of the time during a 30-year base period 1984–2013. The study period is constrained by trends found in streamflow and base flow for long-term continuous-record stations; while USGS has operated many stream-gaging stations, data may be incomplete or nonexistent for some streams. The long-term downward base and low-flow trends from 2013 to 2008 reflect regional changes in climatic and land cover factors such as temperature and/or trade winds and reforestation, and decreases in groundwater storage and recharge which affect base flow.⁷² The CWRM is funding the second phase of a cooperative study with USGS anticipated to be complete in 2021 to provide low flow duration discharges at existing measurement sites and develop methods to estimate selected natural low-flow duration discharges between the 50 and 90 flow-duration percentiles at ungaged sites where streamflow data is limited or unavailable on Maui and other islands using the StreamStat tool.⁷³

In revising the IIFS, the CWRM defined minimum viable habitat flow (Hmin) for the maintenance of suitable instream habitat to support growth, reproduction, and recruitment of native stream animals in Na Wai 'Eha and East Maui streams as 64% of Median Base Flow (0.64 x BFG₅₀; also defined as H₉₀ by USGS studies). For streams without measurable IFS, the IIFS generally reflects the diverted amounts existing when the status quo interim IFS were adopted, or as subsequently amended by CWRM. Low flow conditions, or flow exceeded 90 percent of the time (Q₉₀), is therefore an appropriate starting point for considering additional offstream uses. Significant new stream diversions will require amendments to IFS.⁷⁴ Therefore, in revising the IIFS, the CWRM concluded that establishing continuous stream flow

⁶⁹ Trends in Streamflow Characteristics at Long-Term Gaging Stations, Hawai'i. USGS SIR 2004-5080

⁷⁰ CWRM Staff Submittal, Steam Diversion Works Permit (SDWP.4175.6) Wailuku River, Maui, August 16, 2016

⁷¹ Trends in Streamflow Characteristics at Long-Term Gaging Stations, Hawai'i. USGS SIR 2004-5080

⁷² Cheng, C.L., 2016, Low-flow characteristics for streams on the Islands of Kaua'i, O'ahu, Moloka'i, Maui, and Hawai'i, State of Hawai'i: U.S. Geological Survey Scientific Investigations Report 2016-5103, 36 p.

<http://dx.doi.org/10.3133/sir20165103>

⁷³ CWRM Staff Submittal regarding funding for Second Phase of Cooperative Study to Estimate Low-Flow Characteristics for Streams in Hawai'i, November 15, 2016.

<http://files.hawaii.gov/dlnr/cwrn/submittal/2016/sb20161115A2.pdf>

⁷⁴ Cheng, C.L., 2016, Low-flow characteristics for streams on the Islands of Kaua'i, O'ahu, Moloka'i, Maui, and Hawai'i, State of Hawai'i: U.S. Geological Survey Scientific Investigations Report 2016-5103, 36 p.

from mauka to makai provides the best conditions for re-establishing the ecological and biological health of the waters of Na Wai 'Eha, and used the "Q₉₀" to establish IIFS.⁷⁵

Instream Uses

There are essentially three areas on Maui where instream uses are at issue. The Na Wai 'Eha contested case is within a surface water management area wherein CWRM determines the amount of water the end users are allowed to divert from the streams. The East Maui contested case addresses the instream flow standards and how much water must be left in the streams. In West Maui, CWRM is developing watershed assessments to support a determination of instream flow standards. These are summarized below.

Na Wai 'Eha

Na Wai 'Eha, or “the four great waters of Maui,” is the collective name for the Waihe'e River and the Waiehu, 'Iao, and Waikapu Streams.

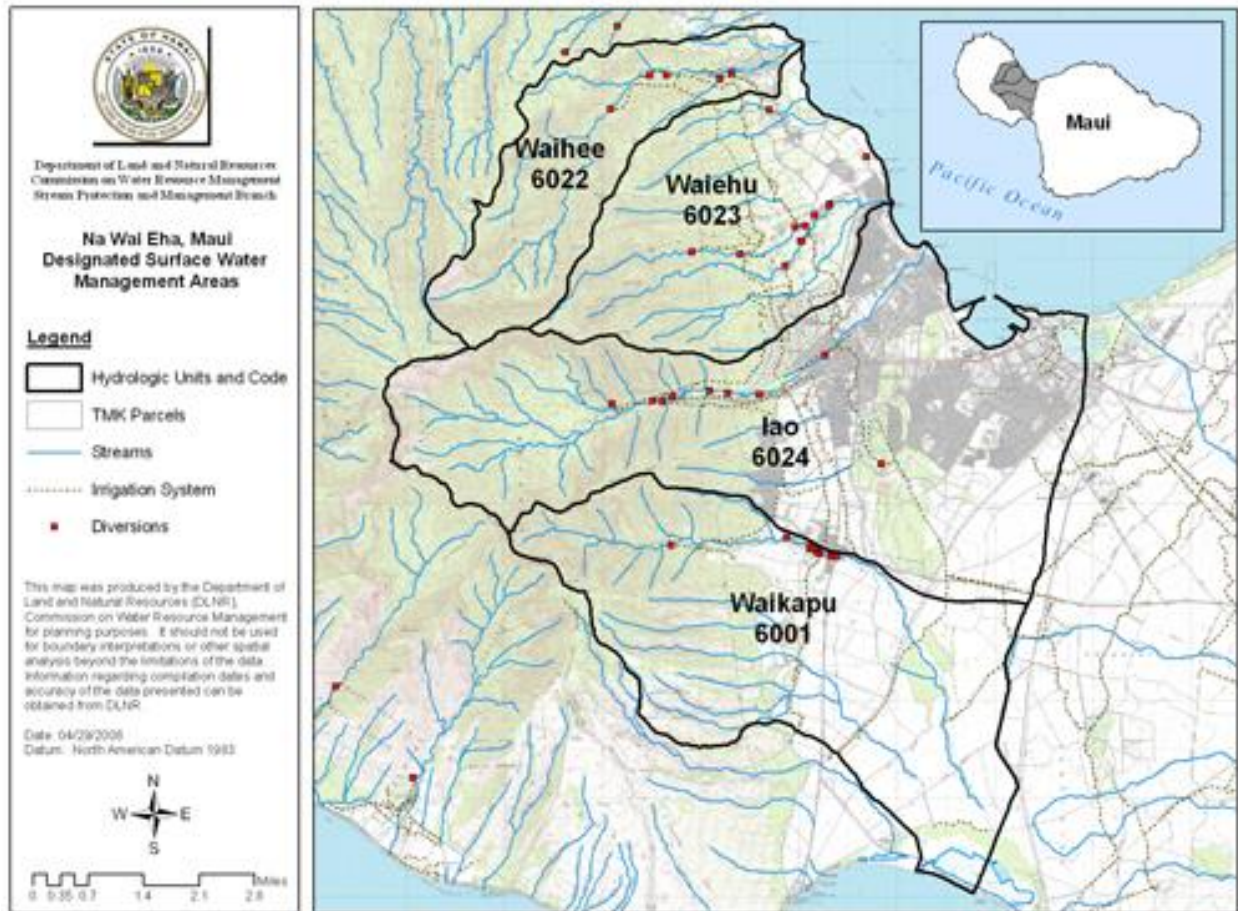
On June 25, 2004 Petitioners/Appellants Hui o Na Wai 'Eha and Maui Tomorrow Foundation, Inc., through Earthjustice, filed a *Petition to Amend the Interim Instream Flow Standards for Waihe'e, North and South Waiehu, 'Iao, and Waikapu Streams and Their Tributaries*, which had been in place since 1988. CWRM designated Na Wai 'Eha as a surface water management area effective April 30, 2008 thereby assuming permit jurisdiction, excluding former domestic consumption of surface water by individual users, for users on any Maui Department of Water Supply water system, and for the use of rain catchment systems to gather water. A contested case addressing Instream Flow Standards (IFS), appurtenant rights and water use permits for Na Wai 'Eha is still ongoing. The first proposed Findings of Fact (FOF), Conclusions of Law (COL), and Decision and Order (D&O) were issued by the Hearings Officer in April 2009. In June 2010, CWRM issued its FOF, COL and D&O, amending the IIFS for Waihe'e and Waiehu streams, while retaining the existing values for Wailuku River and Waikapu Stream. The decision to not amend IIFS values for Wailuku River and Waikapu Stream was appealed to the Hawaii Supreme Court, which ruled that CWRM must consider ecosystem services, habitat for native biota, and traditional and customary practices in establishing IFS values. A mediated settlement of additional IFS values for the two streams was reached between the parties involved, which was approved by CWRM on April 17, 2014.⁷⁶ Under this agreement, more water will be returned to Na Wai 'Eha, particularly to Wailuku River and Waikapu Stream.⁷⁷

Figure 5-10 Na Wai 'Eha -Designated Surface Water Management Areas

⁷⁵ CWRM's Findings of Fact, Conclusions of Law, and Decision and Order in the matter of the "Iao Ground Water Management Area High-Level Source Water-Use Permit Applications and Petition to Amend Interim Instream Flow Standards of Waihe'e River and Waiehu, 'Iao, and Waikapu Streams Contested Case Hearing, June 10, 2010 (CCH-MAO6-O1).

⁷⁶ <http://files.hawaii.gov/dlnr/cwr/cch/cchma0601/CCHMA0601-2-CWRM.pdf>.
<http://files.hawaii.gov/dlnr/cwr/cch/cchma0601/CCHMA0601-2-CWRM.pdf>.

⁷⁷ State Department of Land and Natural Resources, *Maui Parties Reach Agreement In Na Wai 'Eha Amended Interim Instream Flow Water Case*; Press Release, April 21, 2014. <http://files.Hawaii.gov/dlnr/cwr/news/2014/nr20140421.pdf> (May 2015)



On December 14, 2014 the CWRM issued a *Provisional Order on Claims That Particular Parcels Have Appurtenant Rights* (CCH-MA 13-02). The third stage of the contested case process is to determine surface water use permits and the integration of the IFS, appurtenant rights and surface water use permits. However, in response to the January 6, 2016 announcement by Alexander & Baldwin, Inc. that it would close HC&S by the end of 2016 and eventually transition to diversified agriculture, on March 9, 2016 the Parties filed and on July 7, 2016 the CWRM accepted a *Petition to Amend Upward the IIFS for Waihe'e, Waiehu, 'Iao, and Waikapu Streams and Their Tributaries; and Motion to Consolidate or Consider in Parallel with Case CCH-MA 15-01*.⁷⁸ The CCH could potentially conclude late 2017, addressing: 1) applicants for appurtenant rights whose provisional recognitions must be confirmed by CWRM; 2) applicants claiming existing uses; and 3) applicants applying for new uses.

East Maui Streams

⁷⁸ Staff Submittal to the CWRM, June 17, 2016.
<http://files.hawaii.gov/dlnr/cwrmsubmittal/2016/sb20160617C3.pdf>

On May 24, 2001, the Native Hawaiian Legal Corporation (NHLC), on behalf of Na Moku 'Aupuni o Ko'olau Hui (Na Moku), petitioned the CWRM to amend the Interim Instream Flow Standards (Interim IFS) for 27 East Maui streams. In 2008 and 2010, the CWRM approved amendments to the Interim IFS for about half the streams and establishing measurable IIFS of status quo conditions for the remaining streams; only six of the twenty-seven streams had flow restored. In June 2010, the County DWS and the NHLC, on behalf of Na Moku, filed petitions for a contested case hearing before the CWRM. On November 17, 2010, Na Moku appealed the CWRM's decision contending that the CWRM erred in concluding that Na Moku had no right to contest the case hearing and in reaching its underlying decision regarding IIFS amendment for the nineteen streams. On November 30, 2012, the Intermediate Court of Appeals remanded to the CWRM and the contested case hearing began on March 3, 2015. The interest asserted by Na Moku was the right to sufficient stream flow to support the exercise of their T&C native Hawaiian rights to grow kalo and gather in, among, and around east Maui streams and estuaries and the exercise of other rights for religious, cultural, and subsistence purposes. The petition also alleges that the Commission had not carried out its obligations under public trust by failing to require HC&S and EMI to prove: 1) Their actual need; 2) that there are no feasible alternative sources of water to accommodate that need; and 3) the amount of water diverted to accommodate such need does not, in fact, harm a public trust purpose or any potential harm does not rise to a level that would preclude a finding that the requested use is nevertheless reasonably-beneficial.

Subsequent to HC&S announcing cessation of sugar cane cultivation by the end of the year, CWRM ordered re-opened hearings to address HC&S current and future use of surface water and the impact on the groundwater; the impact on DWS's use of surface water due to cessation of sugar operations; the County's position on future use of sugarcane fields, and issues concerning management of the EMI ditch system. In the September Minute Order No. 21, the CWRM hearings officer reiterated the requirement that CWRM weigh competing instream and offstream uses, including economic impact on offstream uses, in amending the IIFS. Should the contested case decision be unfavorable to certain parties, appeals may prolong the case for months or even years.

A&B, Inc. and EMI currently hold revocable permits to take water from four license areas in East Maui. In December 2016 the Board of Land and Natural Resources approved holdover of four revocable permits on a month-to-month basis through December 31, 2017 with amendments capping A&B's extraction of East Maui water at 80 million gallons per day, and ordered full restoration of seven East Maui streams used for taro farming. The Board added Honomanu Stream to the list of streams to be restored.

West Maui

In August 2006 Maui Land & Pineapple Company (MLP) petitioned CWRM to establish amended instream flow standards for Honokohau and Honolua Streams. In November 2008 the CWRM notified MLP that petitions would be delayed due to Na Wai 'Eha contested case. In June 2011 the CWRM entered into an agreement with USGS to conduct a low-flow stream study for 10

streams in West Maui resulting in the report, *Low-Flow Characteristics of Streams in the Lahaina District, West Maui, Hawai'i: Scientific Investigation Report 2014–5087*. The CWRM is currently preparing instream flow assessments.

6.0 SETTLEMENT PATTERNS AND CULTURAL RESOURCES

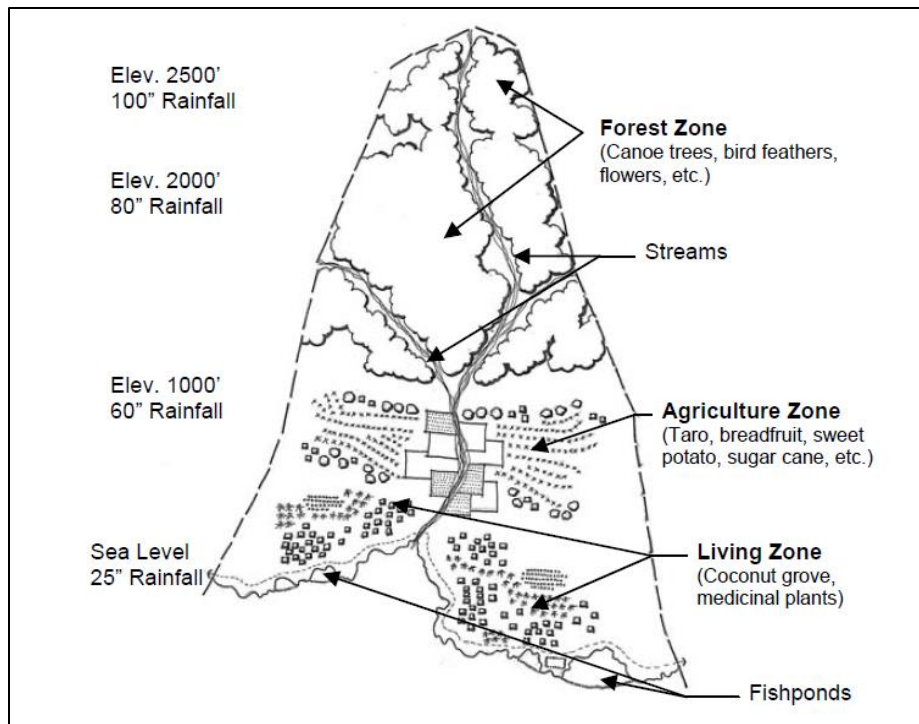
6.1 Overview of Moku and Ahupua'a

Maui County's original inhabitants developed a unique system of land and ocean tenure and use that divided land into large sections called moku. Each moku was comprised of many ahupua'a. An ahupua'a is a land division unit that extends from the upland mountain top to the sea, and usually includes the bounding ridges of a valley and the stream within. In 1853, there were at least 300 villages on the Island of Maui, located in 141 ahupua'a in 12 districts or moku, shown in the figure below.⁷⁹ However, by 1853 Native Hawaiian populations had been decimated by disease. Ahupua'a were intended to support roughly equal numbers of people, but varied in size reflecting the availability of resources. Through this indigenous land-management system based on the ecological interdependence of mauka and makai lands, the Hawaiians employed a complex system of sustainable agriculture and aquaculture practices including extensive auwai (irrigation systems) that were developed to water the lo'i kalo (taro fields).⁸⁰

Figure 6-1 Traditional Ahupua'a

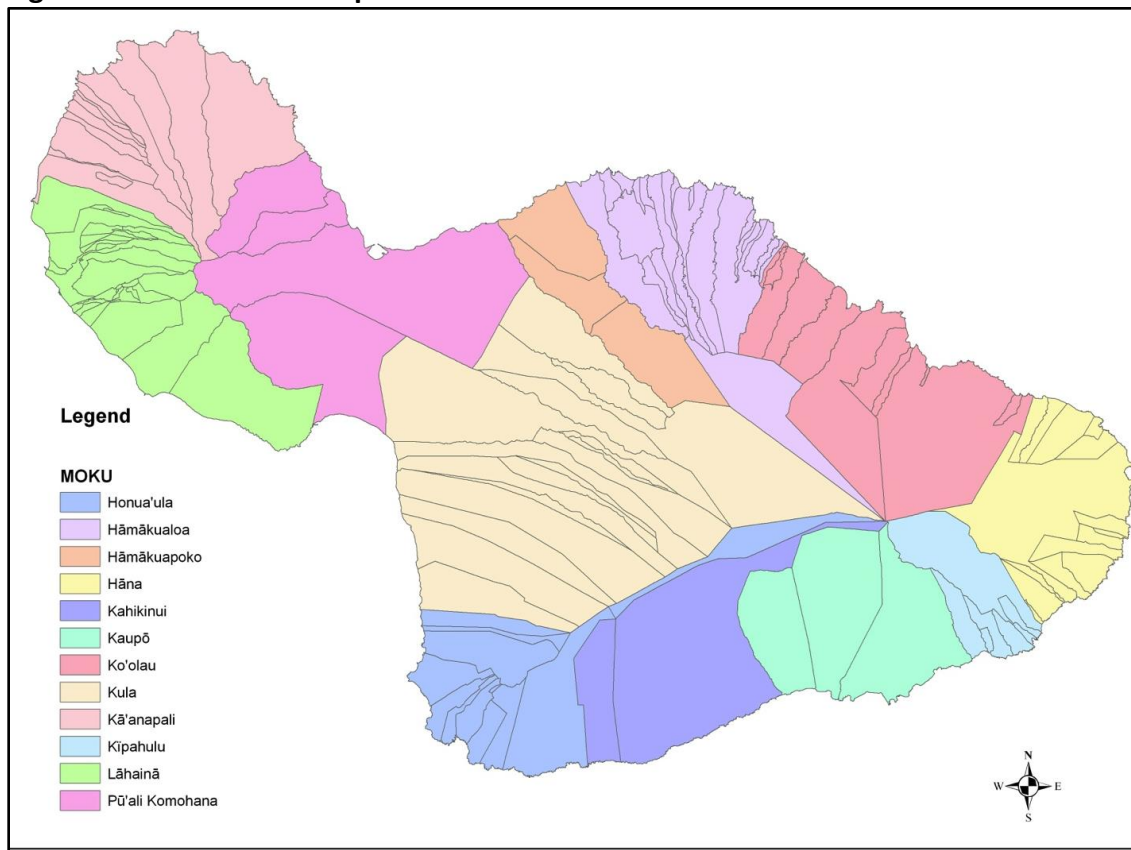
⁷⁹ There are 12 or 13 mokus on Maui Island depending on the historical representation; thus moku boundaries in this WUDP may vary depending on the reference.

⁸⁰ Mauka refers to lands toward the mountain or upland; makai refers to lands toward the ocean.



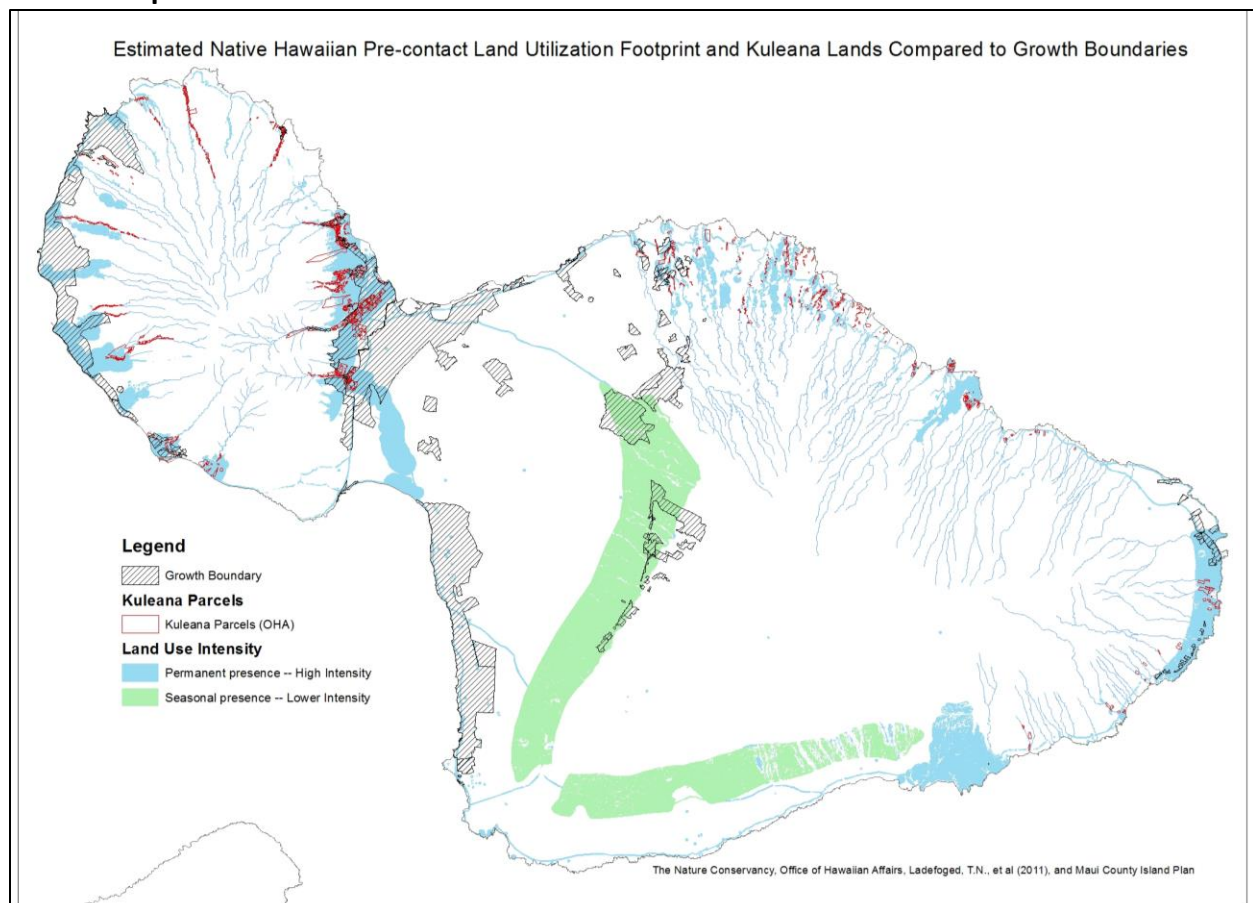
Source: Maui Island Plan, 2012

Figure 6-2 Mokus and Ahupua'a



Land ownership as a concept was first introduced to Hawaiʻi by Westerners. In 1848, King Kamehameha III set into motion the Great Mahele which marked the establishment of Western land-management systems in Hawaiʻi, and included the practice of land division by survey and the privatization of land ownership resulting in a significant impact to the economic framework and cultural fabric of Hawaiian society. Following the events of the Great Mahele, Hawaiian land became widely available for private ownership and development which resulted in many Hawaiians being forced into urban centers and away from lands previous generations had cultivated for over a millennia. This relationship of estimated location of permanent and seasonal pre-contact land use utilization, in comparison to the urban centers represented by the Urban Growth Boundary in the Maui Island Plan, is shown in the following figure. The figure also shows the correlation of pre-contact and kuleana lands compared to the urban centers.

Figure 6-3 Estimated Native Hawaiian Pre-contact Land Utilization Footprint and Kuleana Lands Compared to Growth Boundaries

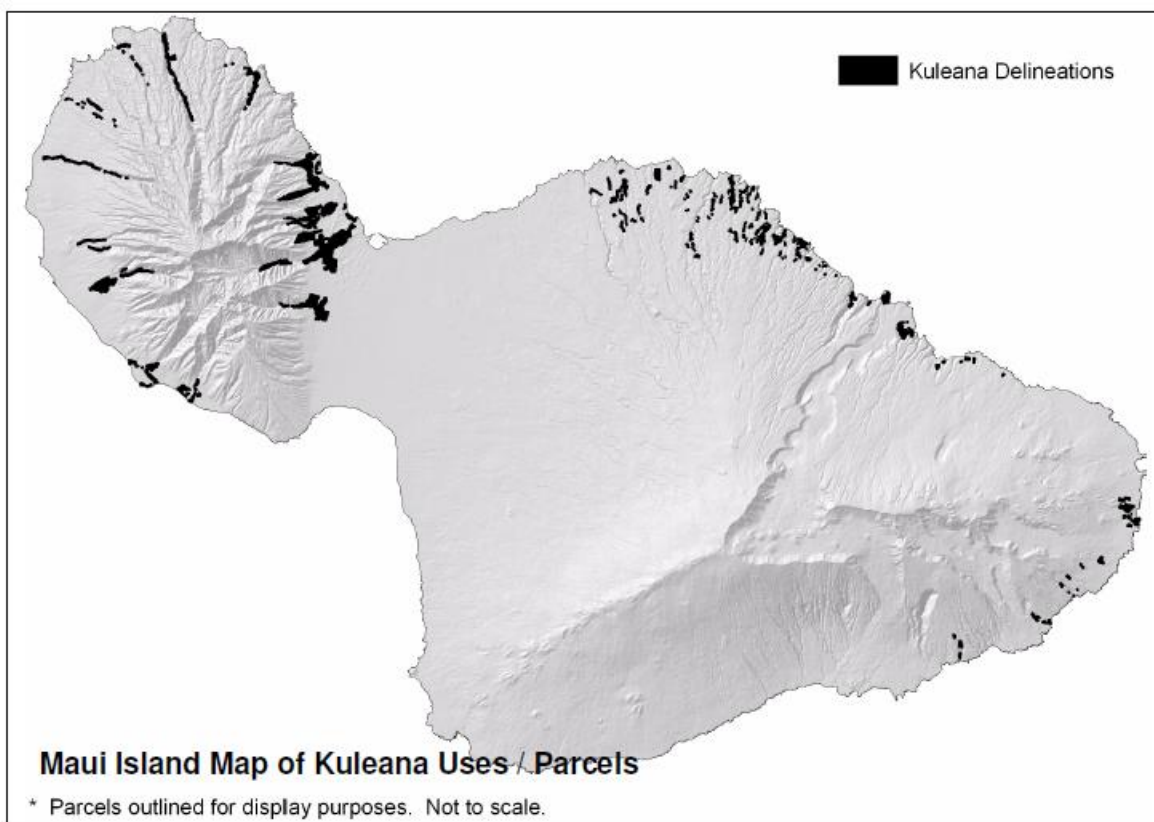


An understanding of Hawaiian customs, practices and indigenous rights in the context of the ahupuaʻa is required in the application of the water law in Hawaiʻi. Native Hawaiian water rights

originate from kānāwai—traditional laws set forth by aliʻi nui (ruling chiefs) for the management and use of fresh water—which were codified in early laws of the Hawaiian Kingdom. Native Hawaiian water rights are protected by the State Constitution and Water Code (HRS Chapter 174C). These water rights include current and future water use for Hawaiian Homelands, domestic water use for kuleana lands, and traditional and customary rights.

Water rights include “appurtenant or kuleana water rights” to use that amount of water from a water source (usually a stream) which was used at the time of the Māhele of 1848 on kuleana and taro lands for the cultivation of taro and other traditional crops and for domestic uses on that land, and “riparian rights” which protect the interests of people who live on land along the banks of rivers or streams to the reasonable use of water from that stream or river on the riparian land subject to other rights of greater value. These rights run with the land.^{81, 82}

Figure 6–4 Kuleana Lands



Office of Hawaiian Affairs data

Traditional and Customary (T&C) Hawaiian practices are deeply intertwined with the geographical environment of the islands. Prior to the arrival of Westerners and the idea of

⁸¹ Haia, Moses. *Protecting and Preserving Native Hawaiian Water Rights*.

<http://www.Hawaii.edu/ohelo/resources/AluLikeWorkbook/Chap7.pdf>

⁸² Ola I Ka Wai: A Legal Primer For Water Use And Management In Hawaiʻi

private land ownership, Hawaiians communally managed, accessed and gathered the resources from the land and seas to fulfill their community responsibilities. T&C Hawaiian rights are personal rights "customarily and traditionally" exercised for subsistence, cultural and religious purposes and possessed by ahupua'a tenants who are descendants of native Hawaiians who inhabited the Hawaiian Islands prior to 1778, subject to the right of the State to regulate such rights. These rights remain in force today. In order to qualify as T&C Hawaiian rights, gathering of stream animals and the exercise of appurtenant rights must meet specified criteria. Not all appurtenant rightsholders have T&C Hawaiian rights because appurtenant rights are property rights held by any owner of the appurtenant lands, while T&C Hawaiian rights are personal rights. T&C native Hawaiian rights are exercised in the streams in the form of subsistence gathering of native fish, mollusks, and crustaceans, and stream flows are diverted for the cultivation of wetland taro, other agricultural uses, and domestic uses that can be traced back to the Mahele. The maintenance of fish and wildlife habitats to enable gathering of stream animals and increased flows to enable the exercise of appurtenant rights constitute the instream exercise of "traditional and customary" Hawaiian rights.⁸³

6.2 Historical "Big Ag" Water Use

Large-scale agriculture, primarily sugarcane and pineapple, drove Maui's economy for over 90 years, with long-lasting impacts on the island's people, land, and water. Due to the 1876 signing of the Hawaiian Reciprocity Treaty allowing duty free admission of Hawaiian sugar to the mainland United States, sugarcane cultivation expanded from 5,080 acres in 1867 to 12,000 in 1880. The pineapple industry began on Maui in 1890 and expanded steadily to cover 28 percent of Maui's cultivated lands by 1930. After World War II, improved economic conditions and increased demand for housing resulted in marginal agricultural lands being converted into urban subdivisions.⁸⁴ Within the past two decades, Maui's pineapple has all but disappeared and has been replaced with seed and diversified crops or other land uses. In 2016 A&B Properties announced that HC&S would halt sugar production at the end of the year, expressing its commitment to future agricultural pursuits on a portion of the lands used for sugarcane production as discussed in section 9.3.

Plantation Irrigation Systems

A key factor to the boom of sugarcane and pineapple was the development of extensive surface water distribution systems in West and East Maui which diverted large quantities of surface water from perennial streams into transmission ditches and tunnels, moving water from the windward side of the islands to the leeward plains. Construction of the East Maui Irrigation (EMI) ditch system was started in 1898, immediately after Alexander & Baldwin acquired HC&S. EMI's water collection system begins in the Ko'olau range in Hāna and has a capacity of 450

⁸³ CWRM East Maui Streams Hearing Officer's Recommended FOF, COL, and D&O, January 15, 2016. Contested Case No. CCH-MA 13-01 <http://files.hawaii.gov/dlnr/cwr/cch/cchma1301/CCHMA1301-20160115-HO-D&O.pdf>

⁸⁴ Maui Island Plan, State Agricultural Water Use and Development Plan, 2004

mgd. The water source is primarily surface water runoff from streams in a 56,000 acre watershed area. EMI, which is owned by A&B Properties, currently leases 33,000 acres of watershed area from the State of Hawai'i. The ditch system in Na Wai 'Eha consisted of two major ditches – Waihe'e and Spreckels ditches – and nine smaller ditches used by Wailuku Water Company (former Wailuku Sugar Company) and HC&S since the late 1800s. The total capacity of the major ditches of Na Wai 'Eha is 100 mgd encompassing a 13,500 acre watershed area. The historical ditch systems are shown below.⁸⁵

Table 6-1 Historical Ditch Systems on Maui (mgd)

Plantation and Ditches	Date	Ave. Flow *	Capacity
<i>East Maui Irrigation Co.</i>		160**	440
(Old) Hamakua Ditch	1878		
(Old) Ha'iku (Spreckels) Ditch	1879	(4)	
Lowrie Ditch (Lowrie Canal)	1900	(37)	60
New Hamakua Ditch	1904	(84)	
Ko'olau Ditch	1905	(116)	85
New Ha'iku Ditch	1914	25	100
Kauhikoa Ditch	1915	(22)	110
Wailoa Ditch	1923	(170)	160-195
<i>Wailuku Sugar Co.</i>		30**	
Waihe'e (Spreckels) Ditch	1882	10-2	20
Waihe'e (Ditch) Canal	1907	27	
Nine other smaller ditches			
<i>Honolua Ranch & Pioneer Mill Co.</i>		50**	
Honokohau Ditch	1904	20	35
Honolua (Honokohau) Ditch	1913	30-18	50-70
Honokowai Ditch	1918	6	50
Kahoma Ditch		3	
Kanaha Ditch		3.8	
Kauaula Ditch		4.5	25.5
Launiupoko Ditch		0.8	
Olowalu Ditch		4	11
Ukumehame Ditch		3	15

AWUDP, 2004, Table 1, Modified after Wilcox, Carol, 1977.

* Average flows are based on the historical record except for those in parentheses, which are from USGS records.

**Estimated average total surface water diverted.

Agricultural Challenges

Prior to its planned demise in 2016, sugarcane cultivation in Central Maui has faced many challenges, including 1) court and regulatory rulings affecting continued access to surface water from East Maui watersheds through the EMI and the West Maui ditch systems; 2) lack of reliable and economically viable markets; and 3) inadequate labor supply. Irrigation demand

⁸⁵ State Agricultural Water Use and Development Plan, 2004

for sugarcane crops averaged approximately around 160 mgd over the past decade.⁸⁶ Persistent droughts and low rainfall periods have adversely affected perennial stream flows and depleted high-level groundwater aquifers that supply Hawai'i's irrigation systems. A 2001 petition to amend the interim instream flow standard for 27 streams in East Maui and restore streamflow, along with the designation of Na Wai 'Ehā as a surface water management area in 2008, rendered the future use of surface water for large scale agriculture uncertain. However, house bill 2501 enacted in June 2016, authorizes EMI to continue diversions by holdover lease until the pending application for the disposition of water rights is resolved, or no longer than three years, whichever occurs sooner.

Between 1980 and 2015, in the State of Hawai'i pasture land decreased by 31% from 1.1 million acres to 761,430 acres, and active agricultural cropland decreased by 57% from 350,830 acres to 151,830 acres. It is highly unlikely that that crop production will ever rebound to the 1980 level, although certain crops such as commercial forestry and seed crops have increased since 1980.⁸⁷ Still, according to the 2015 State of Hawai'i Data Book, Foreign Agricultural Exports on a per-farm-receipts-basis grew from \$151.5 million in 2000 to \$400.4 million in 2014. Although interest in food security, organic produce, farm-to-table dining, and community farmers markets is growing dramatically, Hawai'i's agricultural industry is dominated by export markets.

The agricultural lands in Central O'ahu have become a center for local food production serving both O'ahu and the neighboring islands, as well as providing a model for locally sourced products. Although opportunities may still exist for local exports to O'ahu, Maui and other islands are challenged by the efficiency of O'ahu's larger operations and greater transportation costs than borne by O'ahu's farmers. On Maui, many small farmers need to sell directly to consumers or capitalize on restaurant and resort markets in order to secure a sufficient profit margin. High land values in productive farm areas like Kula along with gentrification are resulting in decreasing farming activities.⁸⁸ Cultivating a continuing and new generation of farmers and labor force is an underlying problem, with first and second generation immigrant farmers generally acknowledged to be the cornerstone of virtually every crop Hawai'i produces.⁸⁹

On Maui, agriculture consumes about 90 percent of total water use and despite the projected decline in production with the close of HC&S is expected to remain a major user. Adequate quantity and low cost water supplies to meet agricultural demand are essential to support the agricultural industry. Maui's water supplies are becoming increasingly constrained due to changes in weather patterns and climate with increasing temperatures, decreasing rainfall and less predictability; population and economic growth; state and county laws, guidelines and their interpretation; stringent application of dam and safety regulations, increased federal farm food safety requirements and regulations requiring potable water to process vegetables; and legal rulings to protect water resources, comply with water rights and the public trust doctrine, and

⁸⁶ HC&S used about 30 mgd (WWC) and 126 mgd (EMI) per Na Wai 'Eha and East Maui Streams Contested Cases.

⁸⁷ Melrose, J., Perroy, R., and Cares, Sylvana, 2015. Statewide Agricultural Land Use Baseline 2015, HDOA, page 4.

⁸⁸ Ibid, pages 5-6.

⁸⁹ Ibid, page 6.

reduce water diversions from streams for both environmental and native cultural purposes (e.g., taro farming). Further, aging infrastructure and new water sources and technologies, such as more pipelines, groundwater wells, recycled water facilities and desalination of brackish sources, are constrained by the availability of capital. Many plantation irrigation systems across the state, including the Maui Land and Pineapple/Pioneer Mill Irrigation System (MLP/PMIS) in West Maui, have been abandoned and are deteriorating and rehabilitation will be extremely costly, and the future of the EMI system also has many pending unresolved issues as sugarcane transitions to other crops or uses. Some small agricultural and kuleana users also use these systems for conveyance. These systems will require strategic reinvestment, subsidies, and incentives in order to support existing and new farm growth.

Hawai'i Statewide Agricultural Land Use Baseline

The 2015 Hawai'i Statewide Agricultural Land Use Baseline provides a snapshot of contemporary commercial agricultural land use activity based on geospatial and other datasets verified by multiple means. It represents the best efforts to capture the scale and diversity of commercial agricultural activity in Hawai'i in 2015 and should be used for informational purposes only. Not all properties were mapped due to the small scale of some operations.

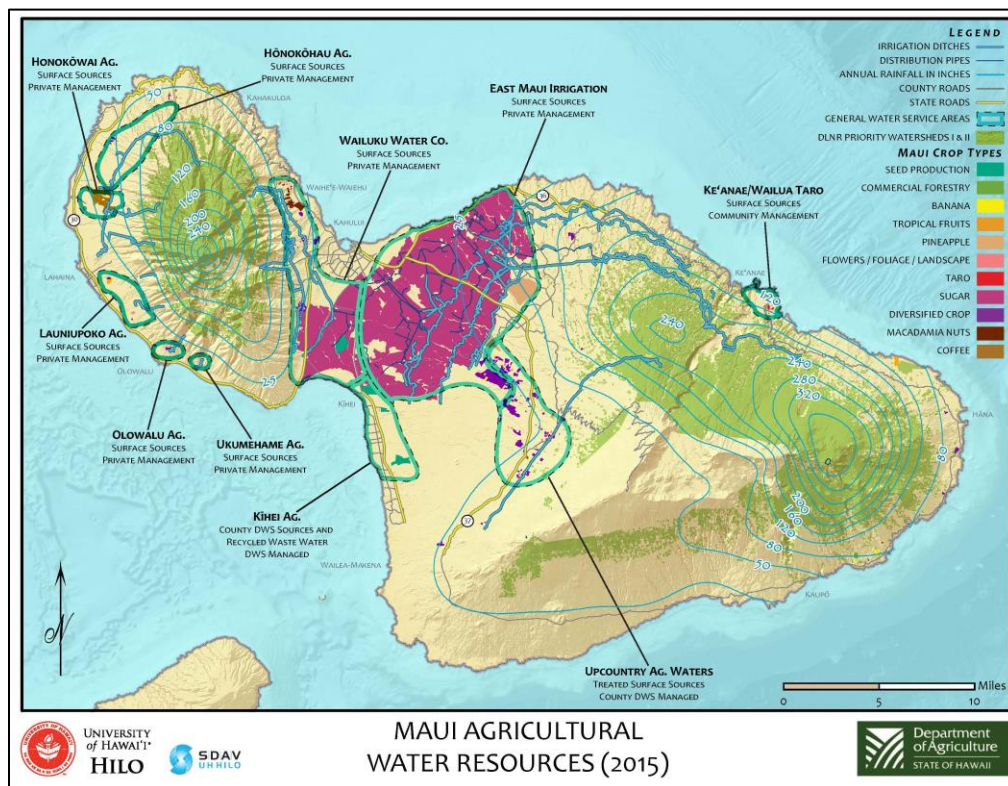
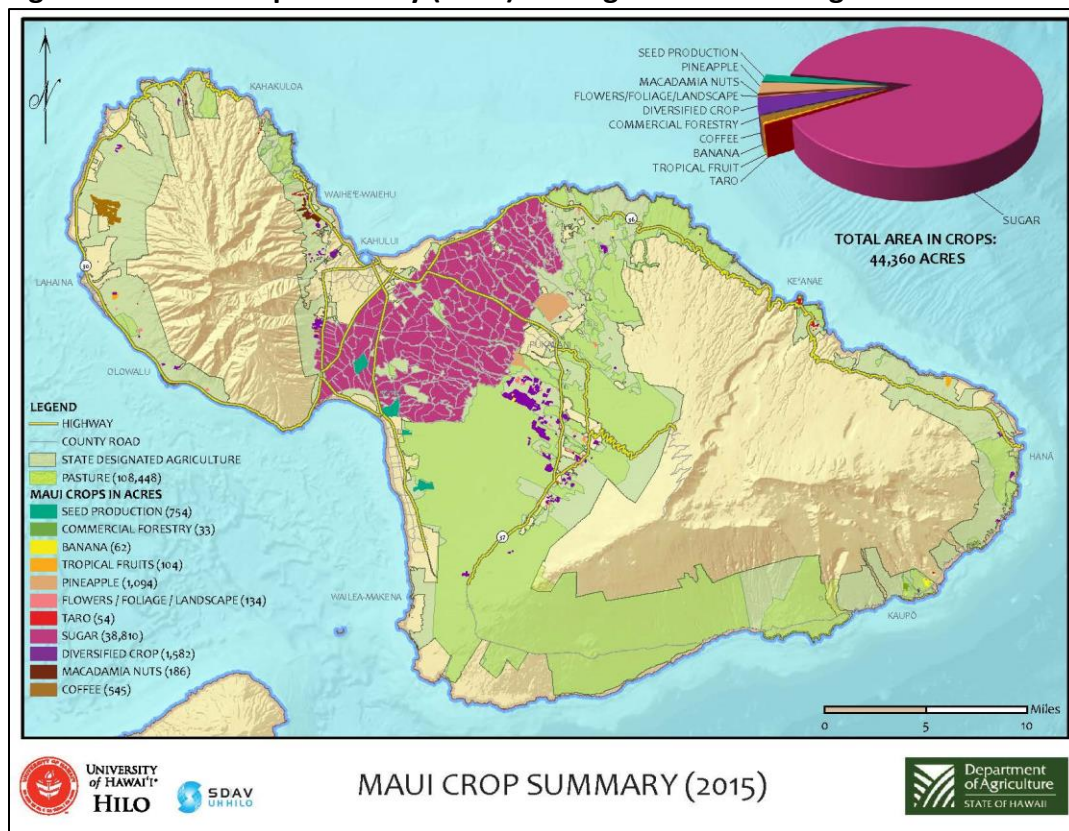
Table 6-2 Agricultural Crops and Acreage on Maui and Average Water Use Rates

Crop	Acreage (2015)	Water Use Rate (gpd per acre)
Banana	62.38	
Coffee	545.35	2,900
Commercial Forestry	33.16	4,380
Diversified Crop	1,582.49	3,400 (2,500 wetter areas)
Flowers/Foliage/Landscape	134.28	4000 – 6000
Macadamia Nuts	186.33	4,400
Pasture	1,093.52	0 – 6700
Pineapple	1,093.52	1,350
Seed Production	754.41	6,700
Sugar	38,810.11	5,556
Taro	54.40	5,400 dryland 15,000-40,000 wetland (consumption)
Tropical Fruits	103.89	4,400 – 10,000
Total	44,453.84	

Water Use Rates - HDOA Guidelines; Coffee: 2004 AWUDP Kauai Irrigation System – 2,500 gpd; 2,900 gpd reported by plantation on O'ahu per Brian Kau, HDOA, personal communication 10/12/2016; Wetland taro: CWRM CC D&O, Na Wai 'Eha and East Maui Streams, sugarcane: HC&S.

The 2015 Maui Crop Summary is shown in the figure below; small acreage operations such as taro production are difficult to see at this scale. The subsequent figure shows the location and sources of agricultural water resources.

Figure 6–5 Maui Crop Summary (2015) and Figure 6–6 Maui Agricultural Water Resources



Melrose, J., Perroy, R., and Cares, Sylvana, 2015. Statewide Agricultural Land Use Baseline 2015: HDOA, page 51.

7.0 EXISTING LAND USE

State land use districts, DHHL land use boundaries, growth boundaries, community plan designations, and zoning districts work in concert to effectively manage land use. State law requires preparation of a WUDP that sets forth “the allocation of water to land use” in each county. Therefore an understanding of land use classifications and their future development potential is necessary.

7.1 State Land Use Plan

The State Land Use classification system provides a framework for county land use planning and local development. There are four land use districts: Urban, Rural, Agriculture and Conservation. The County administers local land use policy within all districts except within the Conservation district which is administered by the State of Hawai'i Board of Land and Natural Resources. The State land use category by acreage on Maui in the table below shows that Agricultural use comprises the largest category.

Table 7-1 State Land Use Category Acreage for Island of Maui

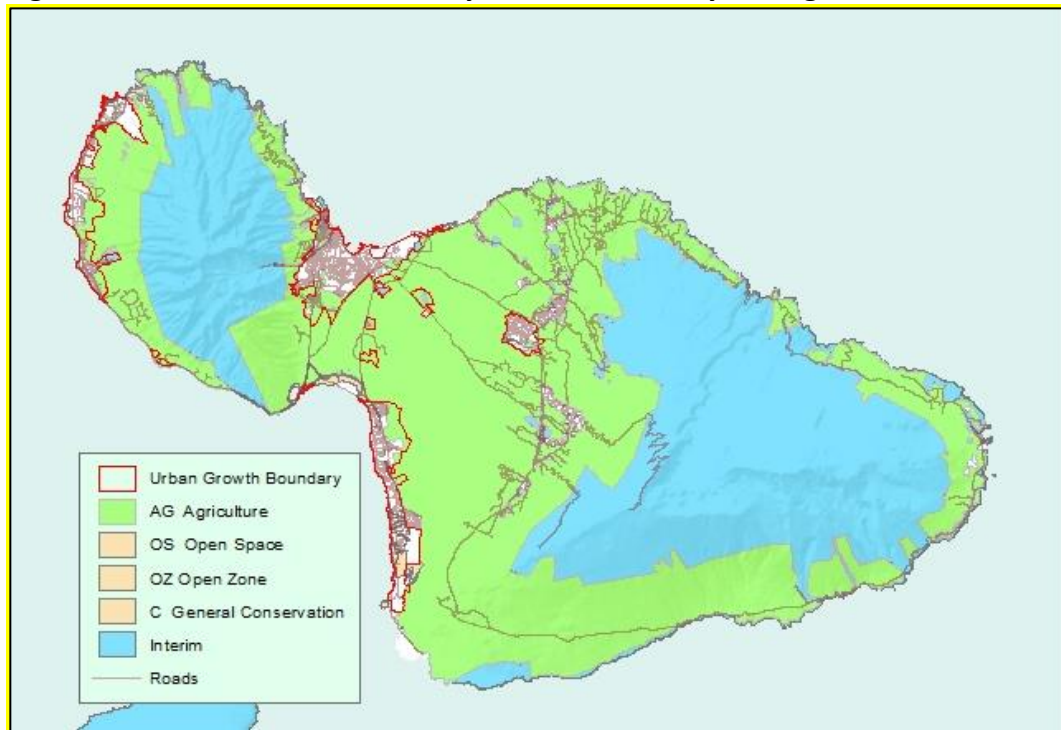
State Land Use Classification	Acreage	Percent of Total
Urban	24,191	5.2%
Rural	4,053	0.9%
Agricultural	242,720	52.1%
Conservation	194,836	41.8%
Total	465,800	100%

Hawai'i Data Book, DBEDT, 12/31/2014. Total differs from Census.

7.2 Maui Island Plan

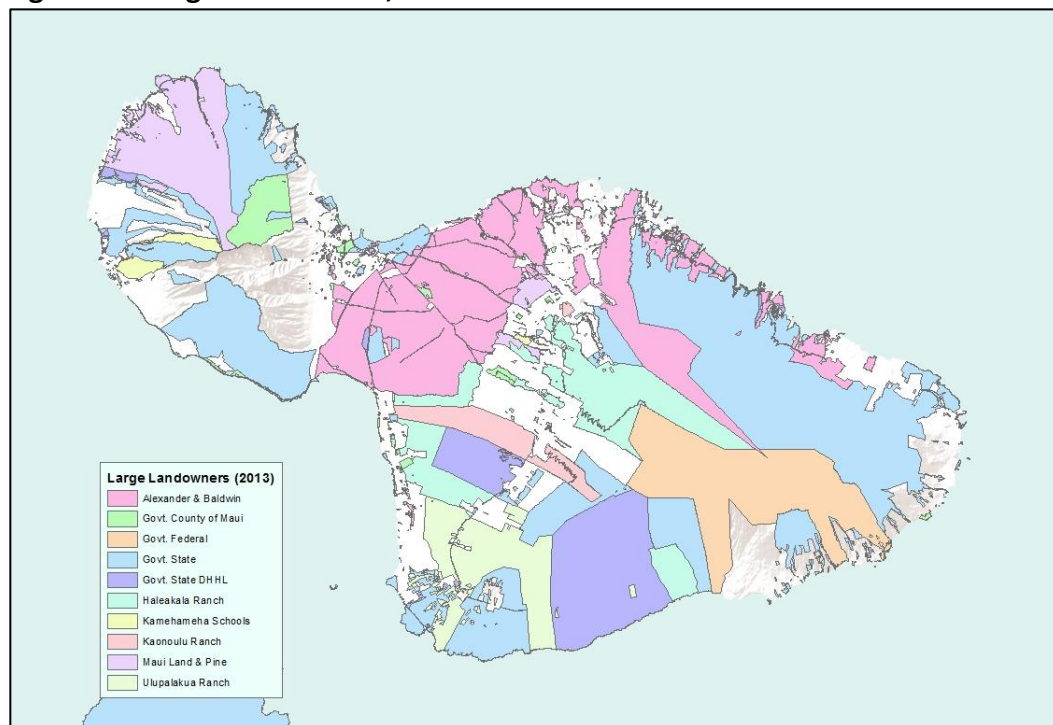
The Maui Island Plan is the guiding county land use plan for the purposes of the WUDP. The MIP establishes Urban, Small Town, and Rural Growth Boundaries (UGB, STB, and RGB) on the Directed Growth Maps. These boundaries encompass approximately 5,389 acres of new planned urban and small town growth areas through 2030. Planned growth is largely directed to Wailuku-Kahului, Kihei and West Maui to protect the character of the existing small towns, rural areas, agricultural lands and open space, and to allow for more dynamic urban settlements with efficient public service delivery. The figure below depicts the Urban Growth Boundary in relation to these low intensity use zoning districts. Most of the lands classified Conservation on the State Land Use Map are zoned Interim. About 5,640 acres of Agriculture zoned land is located within the Urban Growth Boundary.

Figure 7-1 Urban Growth Boundary and Low Intensity Zoning Districts



Government lands encompass about 40 percent of Maui Island, while major landowners account for approximately 70 percent.

Figure 7-2 Large Landowners, 2013



The Comprehensive Zoning Ordinance implements the MIP and sets forth permitted and conditional land uses which support the land use patterns in the MIP and provide a basis for calculating the land use based full buildout water demand projections in section 9.1. Lands within the County are divided into thirteen Use Zone Districts, with some subzones which further regulate land use. The MIP and Community Plans also provide guidance for the Project District zones where large development projects are anticipated. There is also an Interim District where the MIP and Community Plans provide guidance on future land uses; close to 90 percent of lands zoned Interim are essentially planned for open space uses.

7.3 State Department of Hawaiian Homelands (DHHL) Land Use Plans

The Hawaiian Homes Commission adopted its Maui Island Plan as the overarching planning document in 2004. Subsequently the Keokea-Waiohuli, Kahikinui, Leiali'i-Honokowai and Waiehu Kou-Paukaukalo Regional Plans were adopted. DHHL owned 31,337 acres on Maui in 2013 within five planning regions (Hawai'i Data Book, 2014). Regional plans specify land uses and proposed development plans which are summarized in this plan to ensure water sources are adequate for future development.

Table 7-2 Maui Island Hawaiian Home Lands Inventory

TRACT	ACREAGE
West Maui	
Honokōwai	776.5
Central Maui	
Wailuku	0.2
Pu'unēnē	726.0
Waiehu	91.1
Paukūkalo	61.0
Upcountry Maui	
Kēōkea/Waiohuli	6,112.0
ʻUlupalakua	2.0
Kualapa	40.9
East Maui	
Wākiu	743.0
Wailua	91.4
Keʻanae	150.9
South Maui	
Kahikinui	22,860.9
Kalihi/Kanahena	100.0
ʻĀhihi	75.0
Total	31,830.9

DHHL land use categories are summarized in the table below. About 5,000 acres are not assigned to a land use category because future plans are undetermined. Details are provided in the Aquifer Sector Area Reports. This information is used to prepare the land use based water demand projections in section 9.1.

Table 7-3 DHHL Lands Use and CWRM Categories

CWRM Category	DHHL Land Use Category	Acres	% of Total	Water Use Rates (gpd per Acre)
Domestic	Residential (2000.8 acres) Commercial (78.2 acres)	2,079.0 (3,850 Units)	12.7%	600 per unit 6000 per acre
Industrial	Industrial	218.0	1.3%	6000
Agriculture	Agriculture	14,017.5	85.5%	3400
Irrigation	N/A	N/A		
Municipal	Community	137.8	0.5%	1700
Military	N/A	N/A		
N/A	Open Space/Conservation	10,658.0		0
Total		27,110.0	0.05%	

MDWS, Water Resources & Planning Division, May 2015, based on DHHL Maui Island Plan and Regional Plans. Total Acres excludes 5062.5 acres because future land uses are unknown.

8.0 EXISTING WATER USE

8.1 Water Use by Type

The CWRM has established water use categories based on categories of water use for the purposes of water use permitting and reporting. State, MDWS (County), and private public water systems as defined by Department of Health are classified as Municipal. The MDWS billing classes are provided for comparison and reference.

Table 8-1 CWRM Water Use Categories, MDWS Billing Categories

Well Operator	CWRM Category	CWRM Sub-Category	MDWS Billing Classes
	Agriculture	<ul style="list-style-type: none"> • Aquatic plants and animals • Crops irrigation and processing • Livestock water, pasture irrigation, and processing • Ornamental and nursery plants • Taro • Other agricultural applications 	Agricultural
Individual Operator	Domestic Residential Domestic, includes potable and nonpotable water needs Nonresidential Domestic, includes potable (and nonpotable) water needs	<ul style="list-style-type: none"> • Single and Multi-Family households, including noncommercial gardening • Commercial businesses, office buildings • Hotels • Schools • Religious facilities 	<ul style="list-style-type: none"> • Single-Family • Multi-Family • Multi-Family-Low Rise • Multi-Family High Rise, • Housing-County • Commercial • Religious • School-State/Private • Mixed Use • Hotel • Irrigation-Private
Individual Operator	Industrial	<ul style="list-style-type: none"> • Fire protection • Mining, dust control • Geothermal, thermoelectric cooling, power development, hydroelectric power • Other industrial applications 	<ul style="list-style-type: none"> • Industrial
	Irrigation	<ul style="list-style-type: none"> • Golf course • Hotels • Landscape and water features • Parks • Schools • Habitat maintenance 	<ul style="list-style-type: none"> •

Well Operator	CWRM Category	CWRM Sub-Category	MDWS Billing Classes
Agency Operator	Military	<ul style="list-style-type: none"> All military use 	<ul style="list-style-type: none"> US Military Facility
	Municipal	<ul style="list-style-type: none"> State County Private 	<ul style="list-style-type: none"> City Facility State Facility Parks-County/State Irrigation-State/County US Non-Military Facility

The CWRM requires a monthly report of water use from wells operators. CWRM data includes only reported data and therefore is not complete, but it is the best available. In 2014, 63 percent of pumpage was for agricultural use and 28 percent was for municipal use.

Table 8-2 Well Pumpage by CWRM Use Category, 2014

Pumpage	Domestic	Industrial	Agriculture	Irrigation	Municipal	Municipal		Total
						MDWS	Private Public	
Total	0.024	0.208	57.333	4.357	25.126	25.126	4.163	91.213
Percent	0.03%	0.23%	62.86%	4.78%	27.55%	27.55%	4.56%	100.00%

CWRM Well Database, 2014

Domestic Use

Domestic use includes potable and non-potable water use by individual households, commercial uses and quasi-public uses such as religious facilities or schools. These consist of use of individual wells or other sources, and include small water systems that fall outside the Department of Health definition of public water systems.⁹⁰ Owners and operators are responsible for water quality and maintenance of these systems. Information on private wells is collected through the CWRM well construction and pump installation permitting processes. The owner or operator of any well or stream diversion works is required to measure and report monthly usage to the CWRM.⁹¹ It is likely that domestic use is underreported.

Industrial Use

Industrial use can be potable or non-potable water use for fire protection, mining, thermoelectric cooling, and geothermal uses. Industrial use accounts for less than five percent of total water use.

Irrigation Use

⁹⁰ A public water system is a system which provides water for human consumption, through pipes or other constructed conveyances if the system has at least fifteen service connections or regularly serves an average of at least twenty-five individuals daily at least sixty days out of the year.

⁹¹ HAR 13-168-7

The irrigation use category as defined by the CWRM consists of non-potable water uses including irrigation for golf courses, hotels, landscape, parks, schools, and dust control. Irrigation use is determined from CWRM well pumpage data for irrigation wells.

Agricultural Use

Agricultural use includes water use for aquatic plants and animals, crops/processing, livestock and pasture, and ornamental/nursery. As used here, diversified agriculture encompasses all agricultural activities excluding sugarcane and pineapple. On Maui this includes harvesting vegetables, melons, fruits, taro, flowers and nursery products, seed crops, coffee, and macadamia nuts. Livestock and aquaculture also contribute to diversified agriculture on Maui. The majority of diversified agriculture is located within the MDWS Upcountry District and utilizes potable MDWS water.

The CWRM well database provides the following information on well pumpage and pump capacities for agricultural wells, with the preponderance of pumpage in Central Maui supporting sugar cane production.

Table 8-3 Pumpage and Pump Capacity of Reported Agriculture Wells

Aquifer	Pumpage, 2014 Ave (mgd)	Pump Capacity				
		Total	Crops & Processing	Livestock & Processing, and Pasture	Ornamental & Nursery Plants	Aquatic Plants & Animals
Wailuku	0.001	1.036	0.172	0.864	0	0
Lahaina	0	19.886	19.829	0	0.057	0
Central	57.319	236.508	236.148	0	0	0.36
Ko'olau	0.014	8.858	8.019	0.036	0.681	0.122
Hāna	0	0.504	0.36	0.144	0	0
Kahikinui	0	0	0.036	0	0	0
Total	57.333	266.792	264.564	1.044	0.738	0.482

CWRM Well Database; pump capacity of AGR use types 5/29/2015; pumpage, 2014.

In the Ko'olau sector, 0.08 mgd of pump capacity listed as Agriculture has been allocated to crops and processing.

Military Use

According to the Hawai'i Military Land Use Master Plan, July 1995, on the island of Maui there are six acres of land owned by the Department of Defense and nine acres of secondary military use of non-DOD lands⁹². These lands are served by MDWS; billed consumption for 2014 was an average of 20,126 gallons per day.

⁹² Office of Hawaiian Affairs, <http://www.ohadatabook.com/T03-08-13.pdf> (U.S. Department of Defense, Hawaii Military Land Use Master Plan: July 1995 (Honolulu, 1995))<http://www.ohadatabook.com/T03-08-13.pdf>

Municipal Use

Municipal use includes County, State and Federal water uses served by potable public water systems and privately owned public water systems (private public water systems). The State Department of Health (DOH) regulates public systems. Maui's ground and surface water sources must meet Federal Safe Drinking Water Act quality standards administered by the EPA through the DOH.

There are 16 public systems as shown in the table below. Most of these systems are community systems while five serve specific non-residential projects or facilities. As shown in the subsequent table, MDWS systems served 90% of the population. Maps in this WUDP generally display the general location of water systems or their facilities rather than service territories. Groundwater supplies most public water system customers, with the exception of MDWS which also treats surface water. The Haleakalā National Park relies entirely on catchment. The figure below provides the general locations of the public water systems on the island.

Table 8-4 Public Water Systems on Maui Island, 2013

PWS No.	Name	Owner	Type	Population Served	No. of Connections	Average Daily Flow (gpd)	Source
Wailuku Aquifer Sector Area							
212	Wailuku	MDWS	C	68,976	20,287	19,611,000	Ground/ Surface
215	Upper Kula	MDWS	C	7,038	2,346	1,231,000	Surface
240	Hawai'i Nature Center	Hawai'i Nature Center	NC	75	3	300	Ground
249	Kahakuloa	Kahakuloa Acres Water Co.	C	150	48	20,000	Ground
Lahaina Aquifer Sector Area							
204	Kapalua*	Kapalua Water Co., Ltd.	C	4,200	555	450,000	Ground
205	Kaanapali*	Hawai'i Water Service Company	C	8,000	700	2,800,000	Ground
209	Olowalu*	Olowalu Elua Associates	C	100	38	52,000	Ground
214	Lahaina	MDWS	C	18,122	3,236	5,522,000	54% Surface 46% Ground
218	Honokohau	MDWS	C	42	15	13,000	Purchased Ground (PWS 204)
251	MaHānalu Nui Subdivison	Launiupoko Water Co., Inc.	C	587	275	100,000	Ground

PWS No.	Name	Owner	Type	Population Served	No. of Connections	Average Daily Flow (gpd)	Source
Central Aquifer Sector Area							
247	Lower Kula	MDWS	C	3,192	1,064	3,431,000	Surface
254	Maunaolu Plantation	Maunaolu Plant HOA	C	100	37	19,000	Ground
255	Kula Nani	Kula Nani Estates Community Association	C	80	34	-	Purchased Surface (PWS 215)
256	Maui Highlands	Highland Services, LLC	C	26	53	10,000	Ground
258	Consolidated Baseyards	Consolidated Baseyards Association	NT	69	35	83,000	Ground
261	Maui Business Park Phase II	Maui Business Park Phase II Association	NT	65	1	5,000	Ground
213	Makawao**	MDWS	C	28,702	6,675	3,580,000	80% Surface/ 20% Ground
219	Ke'anae**	MDWS	C	270	90	44,000	Ground
Ko'olau Aquifer Sector Area							
203	Kailua	Ohanui Corporation	C	90	27	10,500	Ground
222	Haleakalā National Park	National Park Service	C	1,200	17	4,000	Catchment
252	West Kailua Meadows	W. Kuiaha Meadows HOA	C	45	15	6,000	Ground
Hāna Aquifer Sector Area							
217	Hāna	MDWS	C	1,101	367	319,000	Ground
201	Hāna Water Resources*	Hāna Ranch Partners, L.L.C.	C	816	81	120,000	Ground
220	Nāhiku	MDWS	C	107	43	41,000	Ground
243	Hāna Water Company*	Hāna Ranch Partners, L.L.C.	C	160	88	54,426	Ground
260	Kipahulu	National Park Service	NC	2,000	4	3,000	Ground
				145,313	36,134	37,529,226	

Department of Health, Safe Drinking Water Branch, Sanitary Surveys, performed between 2013 and July 2015.

Data supplied beginning in 2013. DHHL did not report Average Daily Flow.

(C) Community; (NT) Non-Transient, Non-Community; (NC) Non-community.

*Regulated by the PUC, Hawai'i PUC website, January 2016. **Extends into Ko'olau aquifer sector area.

Table 8-5 Comparison of MDWS and Other Public Water Systems

System	Population Served	%	Service Connections	%	Average Daily Flow (mgd)	%
MDWS	127,550	88%	34,123	94.43	33.8	90%
Other	17,763	12%	2011	5.57	3.7	10%
Total	145,313	100	36,134	100	37.5	100
Community Systems only	141,804		36,074		37.4	

DOH, Safe Drinking Water Branch - July 2015. Haleakalā National Park is included in non-community total.

Figure 8–1 General Location of Public and Private Public Water Systems

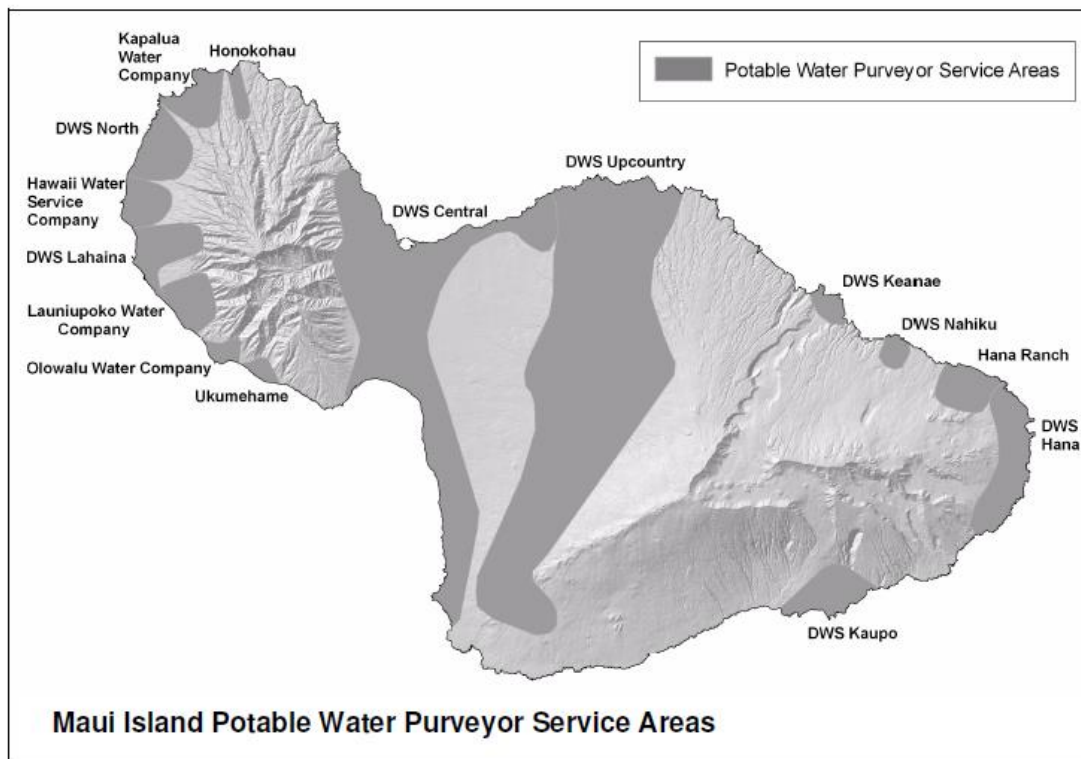


Table 8- 6 Consumption of Public Water Systems by Aquifer Sector on Maui Island, 2014 (gpd)

Aquifer Sector Areas	MDWS	Other Private Public Systems	Other Non-Large Ag Pumpage
Wailuku	4,202,663	0	407,035
Lahaina	5,388,402	3,757,309	271,146
Central	22,234,989	234,761	3,898,093
Ko'olau	995,203	14,908	27,433
Hāna	132,936	156,223	0
Kahikinui	5,222	0	5,111
Total	32,959,415	4,163,201	4,608,818

CWRM Reports, Other pumpage - Excluding Large Ag/Kula Ag

Federal Water Systems

The National Park Service owns the Haleakalā National Park system. The catchment system utilizes a 50,000 gallon water system tank and serves a population of about 1,200 people including visitors.

State Water Systems

A State water system is defined as a water system owned and/or operated by the State that provides water service to State projects or facilities, provides source water and treatment of source water, stores water in storage reservoirs, provides booster pump capacity, conveys water through a distribution system, and distributes water to service connections. A State water system is also defined as when a County or private source supplies a State owned and/or operated water service serving State facilities. On Maui, there are four state water systems owned and operated by the Department of Land and Natural Resources (DLNR), Division of State Parks. There were 23 State owned wells and four stream diversions including those in the table below and the Pokakaekane Stream diversion as of 2003.⁹³ The stream flows supplying the State Parks systems are not gauged or measured and they were not evaluated for surplus source capacity. Future demands were not reported in the State Water Projects Plan.

Table 8-7 State Owned and Operated Water Systems

System	Aquifer Sector/ System	Source	MGD	Use Type
Kaumahina State Wayside (DNLR)	Ko'olau/ Waikamoi	Haipuaena Stream diversion	0.008	Nonpotable, comfort station
Polipoli Springs State Recreation Area	Central/ Kamaole	Unnamed spring	0.002	Nonpotable, park and campground
Puaa Kaa State Wayside (DNLR)	Ko'olau/ Ke'anae	Waiohue Stream diversion	0.006	Nonpotable, comfort station (0.005 MG reservoir)
Īao Valley State Park (DNLR)	Wailuku/ Īao	Īao Stream diversion	Not reported	Nonpotable, 1500 sf taro patch irrigation (Potable supply- MDWS)

State Water Projects Plan, 2003

DNLR – Department of Land and Natural Resources

State Department of Hawaiian Home Lands Systems

DHHL does not own or operate any water supply systems on Maui.⁹⁴ Multiple DHHL properties are served by MDWS within the Central Maui, Upcountry and East Maui regions. Provision of reservations for water for Hawaiian Home Land allotments is a public trust purpose; however,

⁹³ State Water Projects Plan, 2003.

⁹⁴ There are six nonproduction wells and two stream diversions used by individuals on DHHL lands.

the CWRM has not made any reservations per Section 174C-49(d) HRS. MDWS executed a Water Credits Agreement MOU with DHHL dated December 8, 1997 for a reservation of 0.5 mgd for homesites within the MDWS Upcountry District (Kula and Keokea subdistricts) except during drought periods, with no time limit for DHHL to draw or use its reservation. Discussion is underway regarding a water credit agreement to supply the proposed Wakiu project in the Hāna District.

Maui County Department of Water Supply Systems

The Maui Department of Water Supply (MDWS) is responsible for the development, operation and maintenance of the municipal water system and supply. On Maui, MDWS manages nine public water systems as defined by DOH under the State Drinking Water Act, in four districts: Central Maui (Wailuku), West Maui (Lahaina), Upcountry (Makawao), and East Maui (Hāna); each district encompasses a number of subdistricts. The Central and West Maui districts and public water system boundaries are coterminous. The Upcountry district has four interconnected public water systems. The East Maui district has several unconnected public water systems.

The MDWS systems included 750 miles of water lines, 145 storage tanks with 295 million gallons of water storage capacity, six surface water treatment facilities, and 35 groundwater sources for 36,005 customers on Maui in FY 2014. The figure below shows the MDWS water districts, community plan regions, and aquifer sectors.

Figure 8–2 MDWS Districts, Community Plan Boundaries, and Aquifer Sector Areas

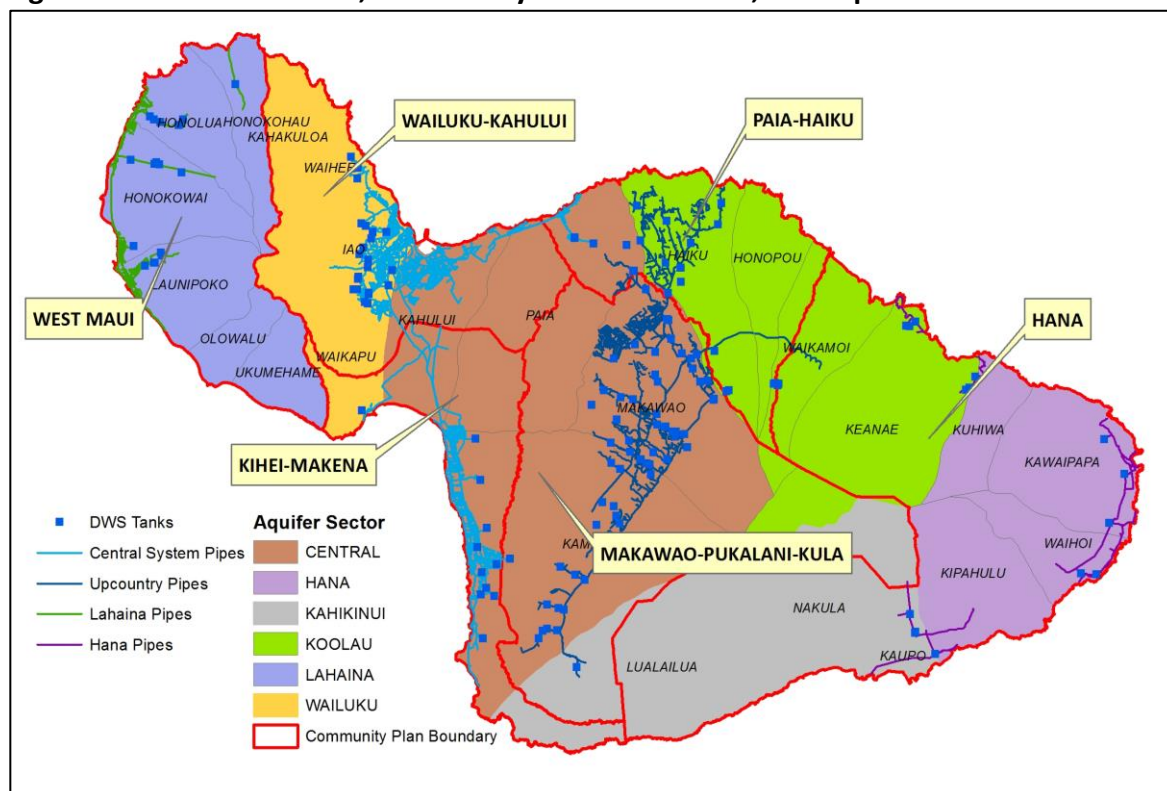


Table 8-8 County Water Systems and Areas Served

District	County Water Systems	Area Supplied	Major Facilities
Central Wailuku	Drinking Water: Central (Wailuku)	Wailuku, Waikapu, Waihe'e, Waiehu, Pu'unene, Sprecklesville, Pa'ia, Kuau, Maalaea, Kihei, Makena	Iao Water Treatment Facility, wells
Upcountry Makawao	Drinking Water: Makawao , Lower Kula, Upper Kula Irrigation: Kula Agricultural Park, State/County System	Haiku, Haliimaile, Makawao, Pukalani, Kula, Ulupalakua, Kanaio	Piihola, Olinda, Kamole Water Treatment Facilities, wells
East Maui Hāna	Drinking Water: Ke'anae, Nāhiku, Hāna Nonpotable- County/Private Shared: Kaupo/Kaupo Ranch	Ke'anae, Nāhiku, Hāna, Hamoa, Koali, Kaupo	Wells
West Maui Lahaina	Drinking Water: Lahaina, Honokohau	Lahaina, Honokowai, Alaeloa-Kahāna, Napili, Honokohau, Ka'anapali region	Lahaina and Mahinahina Water Treatment Facilities, wells

Consumption

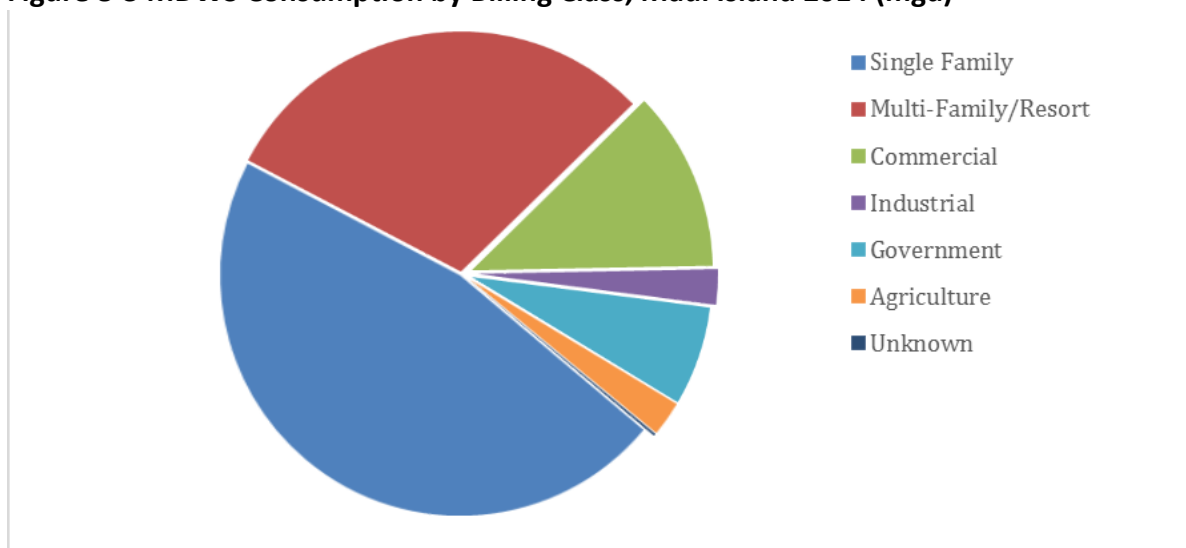
MDWS is a municipal use as classified by CWRM. MDWS categorizes water users and uses by customer class as Single-Family, Multi-Family/Resort, Commercial, Industrial, Government, Agriculture and Unknown. The 2014 consumption billed for all MDWS systems on Maui Island totaled 33.081 mgd. Residential uses, particularly single family uses, generated the largest demand. Nonpotable water billed for agricultural use was limited to an average of 0.12 mgd, within the Kula Agricultural Park subdistrict; excluding Kula Agricultural Park reduces the total billed to 32.959 mgd. All water supplied to the Kaupo subdistrict was billed as nonpotable, consisting of 0.005 mgd for commercial and single-family use. Negligible volumes of water were also billed as nonpotable to limited commercial or industrial accounts in the Kihei, Lower Kula, Makawao and Lahaina subdistricts.

Table 8-9 MDWS Consumption by Class, Maui Island, 2014 (mgd)

Billing Class	Demand	Percent
Single Family	15.406	46.6%
Multi-Family/Resort	9.927	30.0%
Commercial	3.970	12.0%
Industrial	0.765	2.3%
Government	2.182	6.6%
Agriculture	0.778	2.4%
Unknown	0.053	0.2%
Total	33.081	100%

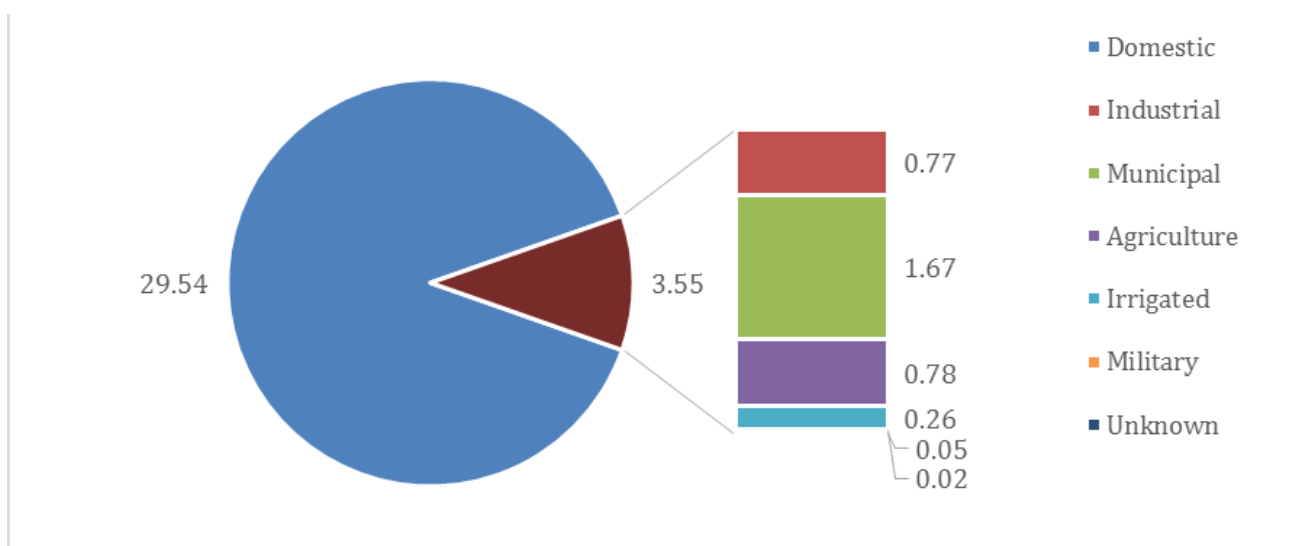
MDWS Metered Consumption, Cal Year 2014

Figure 8-3 MDWS Consumption by Billing Class, Maui Island 2014 (mgd)



Disaggregating MDWS consumption by CWRM categories, domestic uses constitute 89 percent of total demand.

Figure 8-4 MDWS Consumption by CWRM Categories, Maui Island 2014 (mgd)



The Kihei-Makena Community Plan district exhibited the largest demand, while the Central Aquifer Sector Area had the greatest demand as shown in the figure below. Community Plan and Aquifer Sector Areas boundaries are not coterminous except for West Maui/Lahaina.

Table 8-10 MDWS Consumption by Community Plan and Aquifer Sector Area, 2014 (mgd)

Community Plan	Consumption	Percent	Aquifer Sector	Consumption	Percent
Wailuku-Kahului	8.891	26.9	Wailuku	4.203	12.8
Kīhei-Mākena	12.462	37.7	Central	22.235	67.5
Makawao-Pukalani-Kula	5.205	15.7	Ko'olau	0.995	3.0
Pā'ia-Ha'ikū	0.979	3.0	Hāna	0.133	0.4
Hāna	0.155	0.5	Kahikinui	0.005	0
West	5.388	16.3	Lahaina	5.388	16.3
Total	33.081		Total	33.081	

Figure 8-5 MDWS Consumption by Aquifer Sector Area, Maui Island 2014 (mgd)

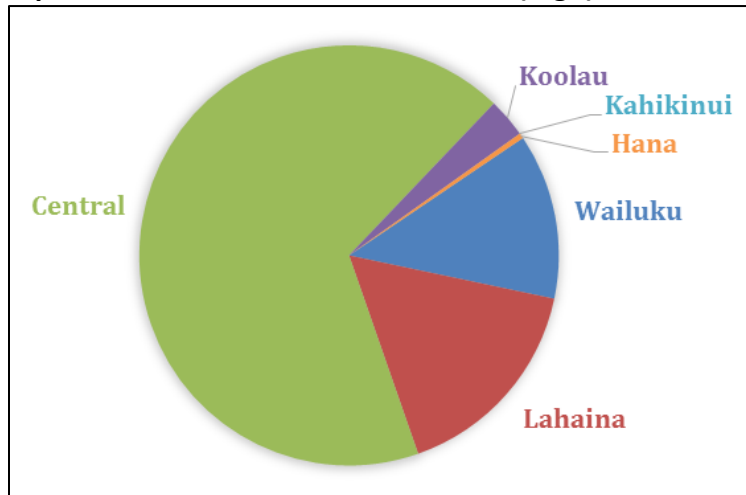
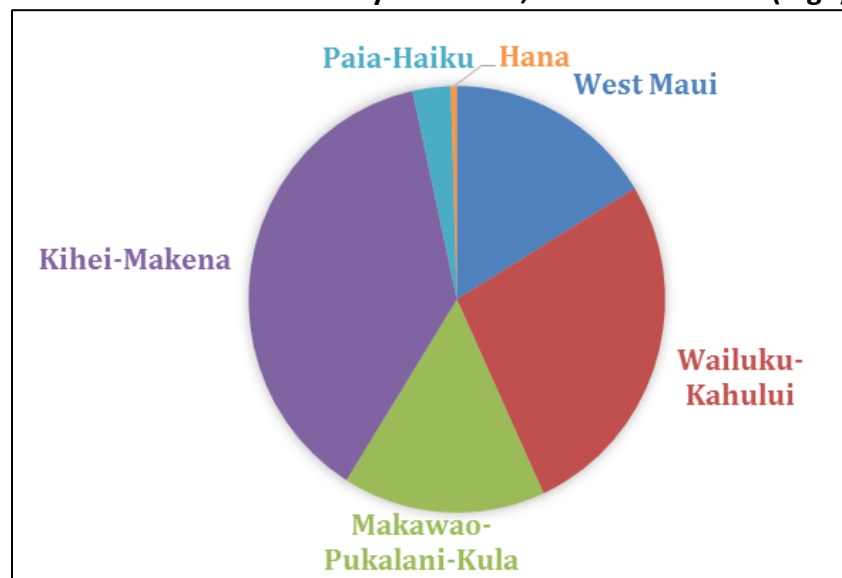


Figure 8-6 MDWS Consumption by Community Plan Area, Maui Island 2014 (mgd)



While the base year for this WUDP is 2014, alternative periods were reviewed to determine whether 2014—which exhibited a strong El Nino—is representative of consumption. The 10-year average was consistent with the 2014 average daily demand. Upcountry demand was about 14 percent lower than the 3-year and 10-year averages. While consumption in the Hāna District was comparatively low in 2014, the area does not face source challenges.

Table 8-11 Comparison of Consumption by MDWS District (mgd)

MDWS District	2014 Daily Ave	3-Yr Ave 2012-14	10-Yr Ave 2005-14	Variation 10-Yr Ave / 2014 Ave
Central Wailuku	21.154	21.299	21.288	1%
Upcountry Makawao	6.263	7.266	7.277	14%
West Lahaina	5.388	5.019	5.163	-4%
East Hāna	0.155	0.174	0.184	19%
Total	32.959	33.753	33.911	n/a

DWS Metered Consumption, 2014 is Calendar Year; other periods are fiscal year.

High year 2005-2014 ave = annual averages for 2012, 2013 and 2014. High year may vary by district.

10 year ave = annual averages, 2005-2014.

MDWS has maintained a priority list of applicants who have been denied water service within the Upcountry Water District pursuant to the Maui County Code, Title 16, Chapter 106. Due to the insufficient water supply in the area, the Board of Water Supply on March 16, 1993 recognized a “shortage condition,” and adopted a *Shortage Finding* stating that the Upcountry water systems did not have sufficient water supply to meet fire protection, domestic, and irrigation needs, and new meters could not be issued without detriment to the existing water services in the regulated area. The *Shortage Finding* affected Upper and Lower Kula, Makawao, Ha’ikū, and Pukalani subdistricts. Following the *Shortage Finding*, since November 2, 1994, MDWS has maintained a priority list of applicants who were denied water service; the list closed on December 31, 2012. As of June 30, 2014 there were 1,822 requests (excluding reservation offered but not accepted, reservation accepted, and meter installed) with an estimated demand of 7.284 mgd. It is estimated that about 50 percent of the requests may result in meters during the planning period for a projected demand of 3.64 mgd.⁹⁵ This issue is discussed in more detail under section 9.2 and in the Central Aquifer Sector Area Report.

Water consumption also varies seasonally, with the low demand months most significantly reflecting lower outdoor irrigation demands. System-wide consumption was about 44 percent higher in August than in March 2014, with the most significant increases in the dryer areas. The high and low months for 2011 to 2015 indicate significant differences in all regions; however, figures for East Maui are not thought to be well correlated with seasonal demand. Thus the large seasonal fluctuations indicate the potential for outdoor water conservation as well as ways to offset use of potable water for nonpotable needs. These findings should also apply to the private public districts that serve community needs.

⁹⁵ MDWS, Maui Island Water Source Development Study, February 11, 2013

Table 8-12 Comparison of High and Low Month Consumption, by MDWS District, 2011 to 2015 (mgd)

District	High Month	Low Month	Variation	% Variation
Central/Wailuku	26.313	15.032	11.281	75%
Upcountry/Makawao	4.886	3.358	1.529	46%
West/Lahaina	5.627	4.209	1.419	34%
East/Hāna	0.188	0.117	0.071	61%
Total	36.306	22.021	14.286	65%

MDWS Billed Consumption (average mgd). High and low months, fiscal years 2011-2015 (mgd). Agricultural Services not included. The figures for the East district are provided but are not indicative of climate conditions.

Per capita consumption has shown a downward trend over time. Due to seasonal and annual variations, long term trends are most reliable. Specific use classes may also be evaluated to evaluate the results of water conservation programs. A per capita rate of 248 gpd is used based on average MDWS 2010-2014 FY and interpolated population.

Table 8-13 MDWS Per Capita Consumption, 1990-2014

Year	Consumption (mgd)	Population (90% of Total)	Per Capita (gpd)
2014 Cal Yr	33.081	139,102	238
<i>2014 Cal Yr, excluding Agricultural Services</i>	<i>30.133</i>	139,102	<i>217</i>
2014 FY	31.761	139,102	228
2013 FY	35.501	136,827	259
2012 FY	33.999	134,551	253
2011 FY	33.119	132,275	250
2010 FY	32.646	130,000	251
2000 FY	33.938	105,880	321
1990 FY	24.243	82,225	295

MDWS Annual Reports; 2014 Cal Year Consumption data

Production

MDWS produced an average of 35 mgd of water in 2014, consisting of 25.1 mgd of groundwater (71%) and 9.9 mgd of surface water. The six MDWS surface water treatment facilities produced over 3.6 billion gallons of water in 2014, representing a decline from 3.9 billion gallons in 2010. The Olinda facility was offline in the last quarter of 2014. The 2014 average daily production was 9.9 mgd; for comparison during the period 2012-2014 the high annual average was 11.677 mgd.

Table 8-14 MDWS Water Treatment Facilities, Annual and Average Daily Production (mg)

WTF	2014 YTD (1000 gal)	ADP (mg)	High YTD Production 2012-2014 (1000 gal)	High Month ADP 2012-2014 (mgd)	% Variation High Yr ADP 2012-2014/ 2014 ADP (mgd)
Lahaina	643.360	1.763	643.360	1.741	0.0%
Mahinahina	560.700	1.536	638.740	1.751	13.9%
West District	1,204.060	3.299	1,210.769	3.308	0.6%
'Iao Ditch	360.513	0.988	409.513	1.120	13.6%
Olinda*	336.690	0.922	546.770	1.494	62.4%
Pi'iholo*	1,044.967	2.863	1,265.306	3.457	21.1%
Kamole*	674.200	1.847	881.770	2.409	30.8%
<i>*Upcountry</i>	<i>2,055.857</i>				
East District	2,416.370	6.620	3063.175	8.369	26.8%
Total	3,620.430	9.919	4273.944	11.677	18.1%

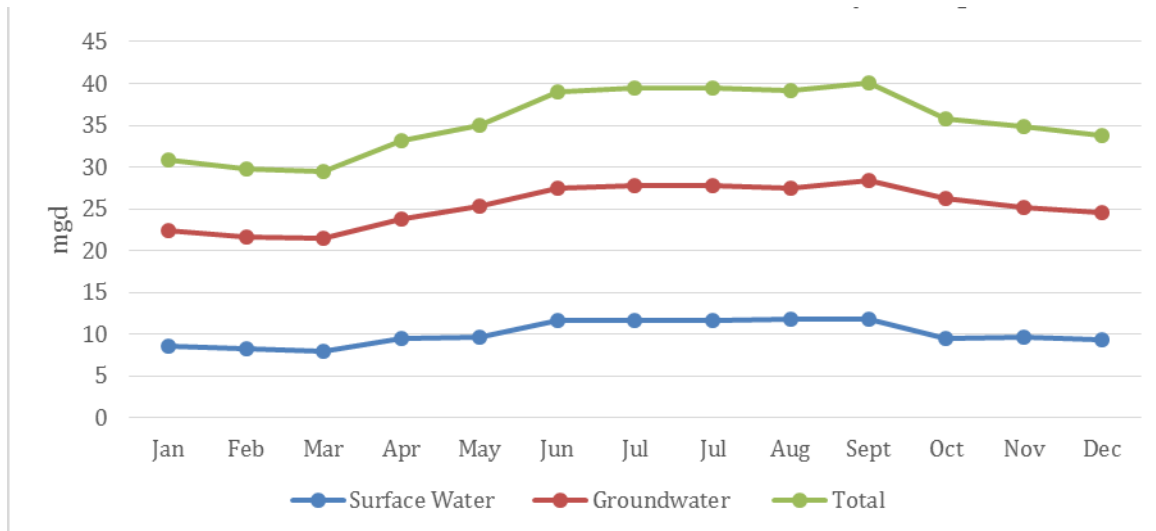
Source: MDWS. *Supplies Upcountry/Makawao system.

YTP= Year Total Production; ADP= Average Daily Production. Olinda was offline in the last quarter of 2014.

High ADP 2012-14 for the individual WTPs did not all occur in the same year.

Since water demand and production vary seasonally, high monthly production is a good indicator of predicted demand and storage capacity utilization. Production of both ground and surface water was highest in September, with an average of 40.2 mgd of water produced. The 10-year peak month production was 45.9 mgd in June 2007.

Figure 8-5 MDWS Production, Maui Island, 2014 Daily Average



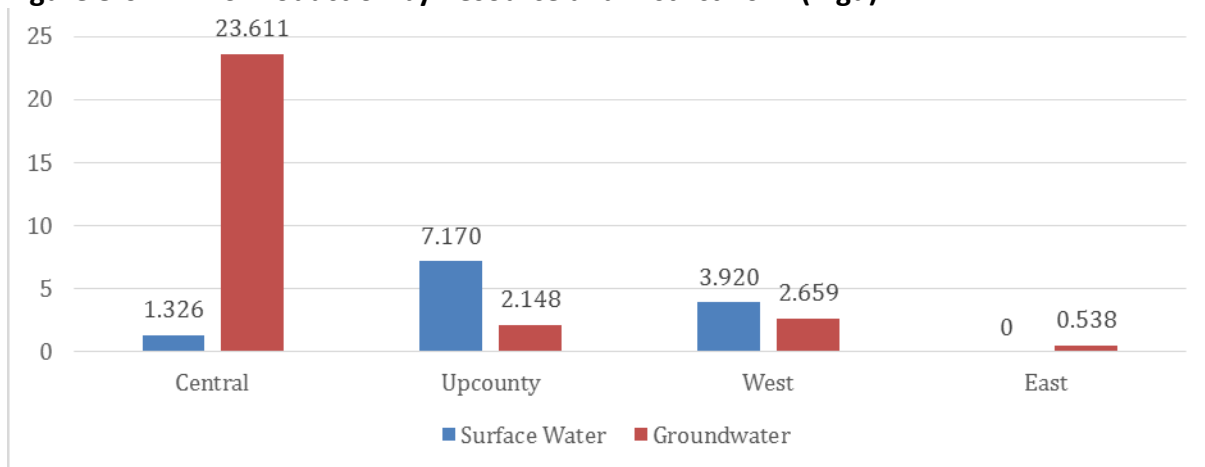
County of Maui DWS, Monthly Water Production, 2014

Table 8-15 MDWS Production by District, 2014 (mgd)

MDWS District	AD Production	High Month AD Surface Water	High Month AD Groundwater	Low Month AD Production	High Month AD Production	% Variation High/Low Month
Central/Wailuku	22.262	1.326	23.611	20.949	24.937	19%
Upcountry/Makawao	6.777	7.170	2.148	4.919	9.318	89%
West/Lahaina	5.509	3.920	2.659	4.789	6.579	37%
East/Hāna	0.504	0	0.538	0.464	0.538	16%
Total	35.052					

MDWS, 2014 Calendar Year. High month production varies by district. High month consumption is August 2014.

Figure 8-6 MDWS Production by Resource and District 2014 (mgd)



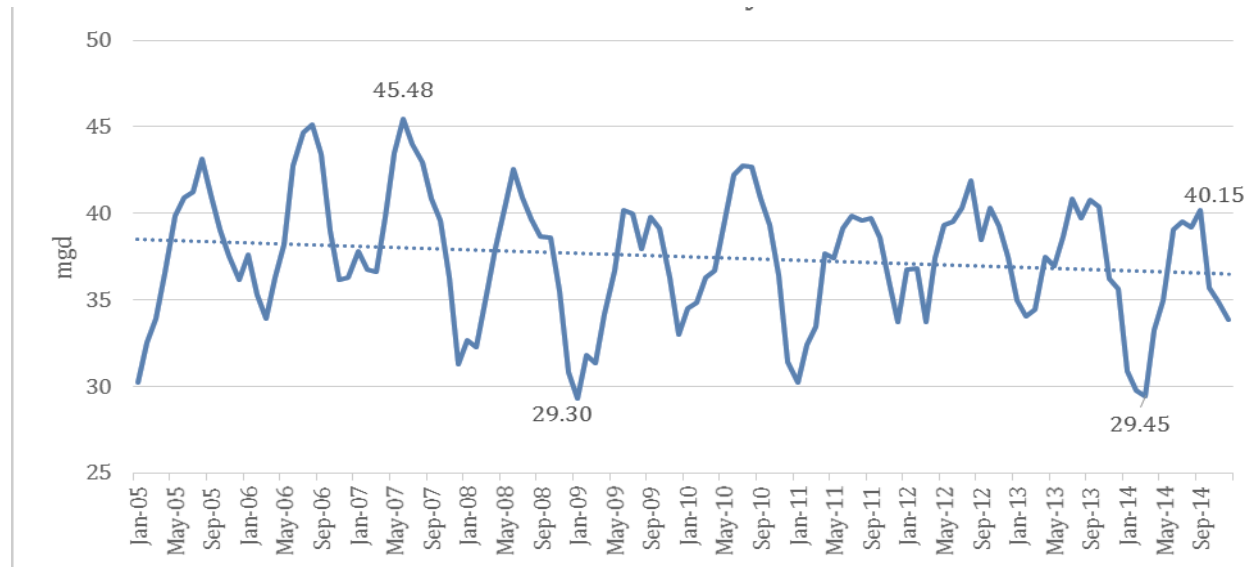
(DWS 2014 Ground and Surface Water.xlsx)

Table 8-16 MDWS Production, 10-Year Daily Average, 2005-2014 (mgd)

District	Total Production			Groundwater			Surface Water		
	Total Daily Ave	High Month Total	% High / Ave Month	Daily Ave	High Month	% High / Ave Month	Daily Ave	High Month	% High / Ave Month
Central/Wailuku	24.06	28.38	18%	23.02	26.91	17%	1.07	1.73	63%
Upcountry/Makawao	7.61	10.36	36%	1.23	2.06	68%	6.38	8.79	38%
West/Lahaina	5.58	6.77	21%	2.35	3.30	41%	3.24	3.92	21%
East/Hāna	0.38	0.61	59%	0.38	0.61	59%	0.00	0.00	0%
Total	37.66	46.12	22%	26.98	--	--	10.68	--	--

MDWS production, 2005-2014 (mgd). Daily averages are over 10-year period. High month groundwater (GW) and surface water (SW) for the various districts are not totaled because they did not all occur in the same year. The figures for the East district are not indicative of climate conditions.

Figure 8-7 MDWS 10 Year Historic Production (mgd)



(DWS 2014 Ground and Surface Water.xlsx)

Water Losses

Total water loss is generally calculated as the difference between production at the source and billed consumption. MDWS average daily production in 2014 and on average over the past 10 years exceeded consumption by about 6% system-wide. While not directly comparable, the comparisons reflect operational and use efficiency. Unbilled production was less than 0.1%. Water loss reduction through water audit, leak detection and other measures are addressed under the Conservation Section (*this section is in progress*).

Privately Owned Public Water Systems

There are 16 privately owned public water systems on Maui. The largest private water purveyor is the Hawai'i Water Service Company which serves several large resorts, commercial and residential properties near Ka'anapali in West Maui. Private public water system data is based primarily on reported pumpage or average daily flow data derived from the Department of Health. More information is provided in the Aquifer Sector Area Reports. Water system operators were queried regarding existing conditions and future service projections; however, only limited data was received. Most data provided by private public water systems is not categorized by use.

Privately owned public water systems present an alternative to the MDWS systems when new developments are built outside MDWS service areas consistent with County land use policies and directed growth strategies. Issues of concern include management and monitoring of private water systems to ensure the long-term sustainability of the island's water resources,

competition for water resources, proper well maintenance and abandonment as related to water quality.

Other Potable Water Use

An unknown number of persons are not served by any public water system. Some small developments or groups of development below the DOH threshold or individual households and uses may be served by domestic wells, catchment, streams or other sources. Estimated 'order of magnitude' demand for 2014 of 0.277 mgd was based 2010 Census Block population of about 1,190 persons that appeared to be outside public water system purveyor service areas based on general location of development and system pipes and an average MDWS per capita rate of 248 gpd.⁹⁶ Information on water demand for public systems and estimated unserved population is provided below.

Table 8-17 Summary of Potable Water Demand, 2014

User	2013 DOH	2014	2014 Notes
MDWS	32.792	32.959	Billed consumption (excludes Kula Ag Park- 0.12 mgd)
<i>MDWS</i>		<i>35.052</i>	<i>Production (Pumpage and WTF production – 25.126+9.919 =35.045)</i>
Private Public Systems	3.737	4.163	Pumpage
Public Water Systems	37.529	37.122	
Domestic Wells	--	0.024	Pumpage
Unserved Population	--	0.276	Estimate, excludes domestic well pumpage reported to CWRM
Total	37.529	37.422	

CWRM Reports, DOH, and MDWS Consumption Data.

8.2 Water Use by Resource

Existing water resources include ground water, surface water, rainwater, reused rainwater (stormwater, catchment), recycled wastewater and greywater, and desalinated water. Fresh water is defined as water that contains less than 1,000 milligrams per liter (mg/L) of dissolved solids. Maui has exhibited the highest freshwater use of the Hawaiian Islands.⁹⁷

Table 8-18 Fresh Water Use Maui Island (mgd)

Use	Maui Island	
	2014	% of Total
Groundwater	91.21	25.20%

⁹⁶ 2010 Census Block Group population that appears to be outside public purveyor service areas – approx. 1190; apply average MDWS per capita rate of 248 gpd based on 2010-2014 consumption and interpolated population = 296,144 gpd. Excluding domestic well pumpage of 20,495 gpd results an estimated demand of 276,649 gpd.

⁹⁷ Volcanic Aquifers of Hawai'i—Hydrogeology, Water Budgets, and Conceptual Models, p 87.

Public supply	29.29	32.11%
Domestic	0.02	0.03%
Industrial	0.21	0.23%
Irrigation/Ag	60.17	65.96%
Livestock	1.04	1.14%
Aquaculture	0.48	0.53%
Surface Water	270.70	70.00%
Public supply	10.88	4.02%
Domestic		
Industrial	6.66	2.46%
Irrigation	253.16	93.52%
Total	361.91	100.00%

Source: CWRM Reports and characterization of HC&S water use, Petition to Amend the Interim Instream Flow Standards for East Maui Streams Contested Case, Hearing Officer's Proposed FOF, COL, D&O, January 15, 2015, page 135 (Resource Assessment.xlsx, Resource Use sheet)

8.2.1 Ground Water

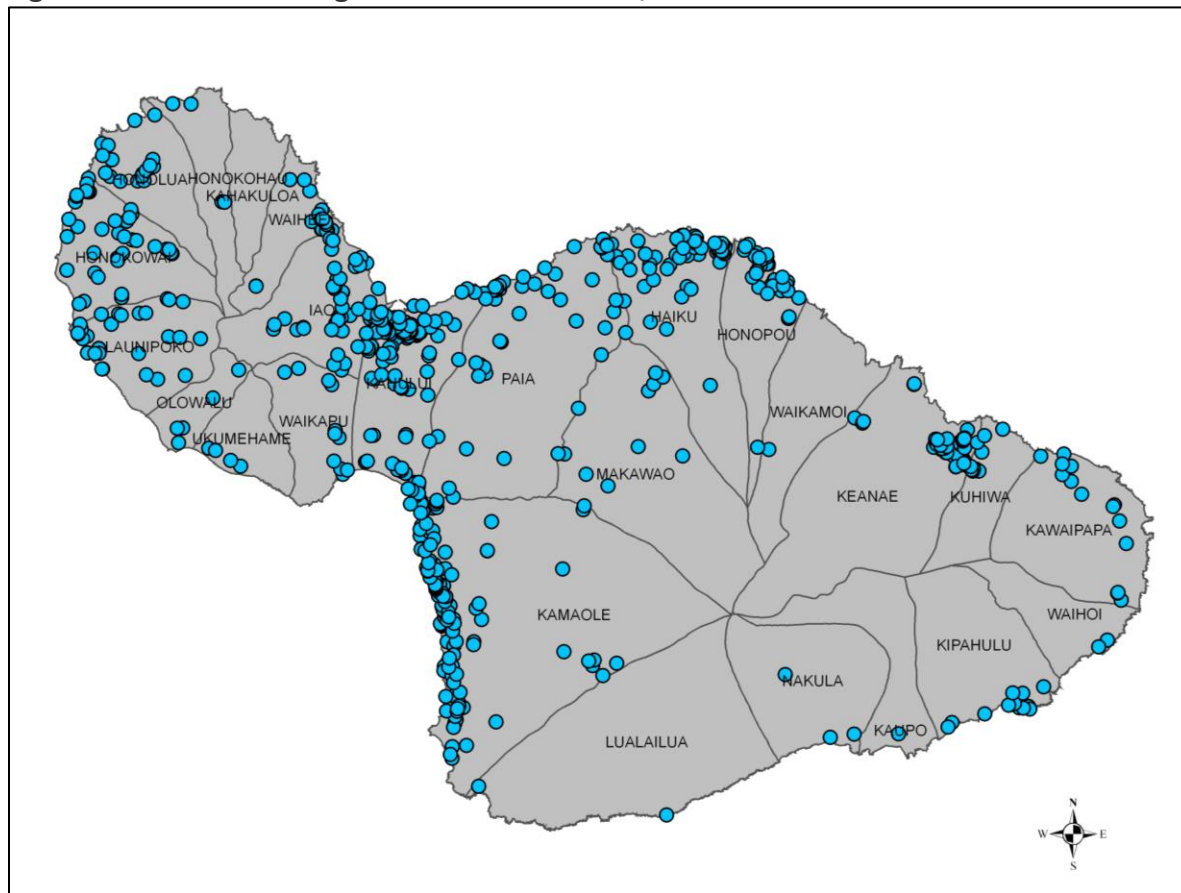
"Well" is defined by the Water Code as, "an artificial excavation or opening into the ground, or an artificial enlargement of a natural opening by which ground water is drawn or is or may be used or can be made usable to supply reasonable and beneficial uses within the State. The inventory of wells was obtained from the CWRM database which was developed with information received from the Well Registration program and since 1988 has been supplemented with well construction and pump installation permitting information. The database is the best available information and was used to evaluate the existing ground water resources. However, it is not complete and lacks information pertinent to the WUDP for many of the wells, such as installed pump capacity. On January 22, 2014, the Commission required all wells in the State of Hawai'i to report monthly ground water use including quantity pumped, chloride (and/or conductivity) concentrations, temperature, and (pump off) water-level data. Continued exemptions include the following, "UNLESS the Commission determines a specific need for this data to resolve disputes, establish instream flow standards, or quantify the amount of water for a water use permit in a water management areas, or for similar needs:

- (a) Passive agricultural consumption (e.g. when crops are planted in or adjacent to natural springs and natural wetland areas);
- (b) Livestock drinking from dug wells or stream channels;
- (c) In non-surface water management areas, individuals on multi-user ditch systems where IFS or water use permits are not an issue;
- (d) Salt-water wells may continue to report monthly *estimates* of pumpage and monthly *actual measured* water-levels and salinity on an annual basis."⁹⁸

⁹⁸ CWRM Meeting, January 22, 2014. <http://files.hawaii.gov/dlnr/cwrmm/submittal/2014/sb201401D1.pdf>

In 2014 there were 832 registered wells on Maui Island, of which 528 were production wells assigned the CWRM use categories shown in the table below. The remainder were classified as observation, other, unused, abandoned or not specified. Nonagricultural irrigation wells comprise the largest number of wells (249), predominately located within the Central Aquifer Sector Area. Reported pumpage is summarized below.

Figure 8-8 Location of Registered Wells on Maui, 2014



CWRM, GIS Well Database. Not all well locations are shown.

Table 8-19 Reported Pumpage by Well Use Type, Maui Island 2014 Daily Average (mgd)

Aquifer	Domestic	Industrial	Agriculture	Irrigation	Municipal	Municipal		Total
						MDWS	Private Public	
Wailuku	0.006	0	0.001	0.400	20.354	20.354	0	20.761
Lahaina	0	0	0	0.271	5.936	2.179	3.757	6.207
Central	0.007	0.208	57.319	3.683	1.507	1.272	0.235	62.724
Ko'olau	0.008	0	0.014	0.002	0.892	0.877	0.015	0.916
Hāna	0.004	0	0	0.001	0.6	0.444	0.156	0.606
Kahikinui	0	0	0	0	0	0	0	0
Total	0.024	0.208	57.333	4.357	25.126	25.126	4.163	91.213

Source: CWRM Well Database, 2014.

The table below compares pumpage and pump capacity to sustainable yield. Installed pump capacity is important because it indicates the maximum quantity of water that hypothetically could be drawn. Pumping capacity is available for only 318 of the 526 registered wells in use in the CWRM well database and totals 422 mgd. However, pump capacity exceeds sustainable yield for the Wailuku, Lahaina and Central Aquifer Sector Areas.

Table 8-20 Pump Capacity and Pumpage of Wells in Production Compared to Sustainable Yield (mgd)

Aquifer Sector	Pump Capacity	Pumpage (2014 Ave)	Sustainable Yield	% of Aquifer Pumped	% of Aquifer Potentially Pumped
Wailuku	70.812	20.761	36	58%	197%
Lahaina	53.181	6.207	34	18%	156%
Central	279.637	62.724	26	241%	1076%
Ko'olau	14.314	0.916	175	1%	8%
Hāna	3.717	0.606	122	0%	3%
Kahikinui	0.282	0	34	0%	1%
Total	421.943	91.214	427	21%	

CWRM Well Index 5/29/2015. Does not include unused, other, unspecified, abandoned or observation use wells.

At the aquifer system level, well permits have been issued allowing significantly higher pumpage than sustainable yield without apparent negative impacts due to agricultural irrigation return water. Pumpage exceeded sustainable yield in the Kahului and Pa'ia Aquifer System Areas by 3,000 percent and 422 percent respectively in 2014 due to agricultural demand. For the 'Iao Aquifer System Area, which is a groundwater management area, 86% of the sustainable yield was pumped, primarily for municipal demand, while over 95% of the sustainable yield has been allocated by the CWRM. The table below provides pumpage information for Aquifer System Areas which were close to or exceeded sustainable yield, or may potentially exceed sustainable yield based on pump capacity.

Sustainable yield does not address whether groundwater is potable or brackish or constitutes agricultural return water, which supports pumping in excess of the sustainable yield within the Kahului and Pa'ia Aquifer Systems. Termination of sugarcane operations in the Central region is likely to significantly reduce irrigation return water and affect groundwater availability and quality, but should not affect sustainable yield. The sustainable yield of the windward sides of the island, where growth is limited and not projected to substantially increase, greatly exceeds permitted and actual use.

8.2.2 Surface Water

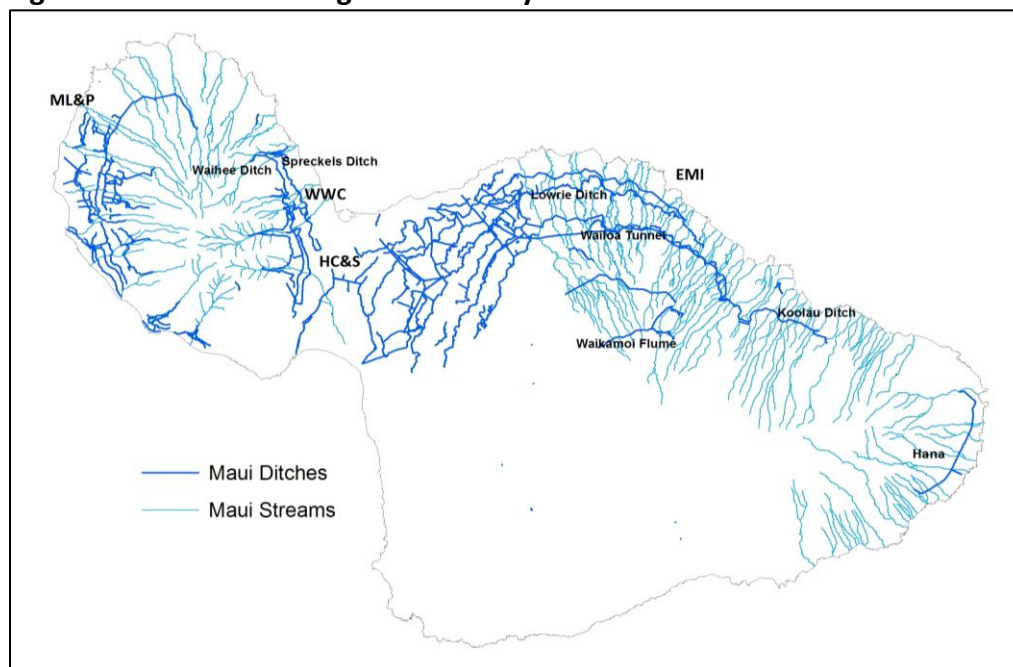
Surface water use is difficult to quantify due to a lack of surface water use data and information on stream diversions, changes in water use by large-scale agricultural systems, and difficulties associated with measuring diverted flow. The major ditch and flume systems constructed by the historical plantations remain in use today, supplying agricultural, municipal and other uses,

including kuleana uses. Due to increasing concern regarding surface water issues the CWRM on January 22, 2014 amended its policy allowing exemptions from the requirement to measure and report monthly water use to Stream Protection and Management Branch. Continued exemptions are the same as for groundwater described in the previous section.⁹⁹

Stream Diversions

The major surface water systems included the East Maui Irrigation (EMI), Wailuku Water Company (WWC), and Maui Land and Pine (MLP) and Pioneer Mill systems, as shown on the following maps. The CWRM database lists 488 stream diversions and surface water gage records reported to CWRM indicate the average diverted flow was 407.5 mgd in 2014. However, while historically plantation ditch operators maintained detailed records of rainfall conditions and diverted flows, different portions of some systems may now be under varying ownerships and flow monitoring gages may no longer exist or be useful for monitoring the total diverted flow. Gages located at key locations along the length of the system may in some cases double count flow. While the inventory of diversions is currently being updated and verified, much of the declared stream diversions and surface water use data is unverified, conflicting or incomplete, and is therefore of limited use. The locations and distribution of diversions and gages are listed in Appendix 4. On Maui, ground and surface water is transported to adjacent or distant aquifers by ditches or pipes for conveyance to uses in that area. Large-scale transport of surface water in particular is a significant legal, community, cultural and ecological issue. Water systems as well as recycled wastewater systems may also span more than one watershed or aquifer system area resulting in localized transport.

Figure 8–9 Plantation Irrigation Ditch Systems



⁹⁹ CWRM Meeting, January 22, 2104. <http://files.Hawai'i.gov/dlnr/cwrn/submittal/2014/sb201401D1.pdf>

In 2014 agriculture continued to account for most of the surface water diverted from Na Wai 'Eha and East Maui streams. HC&S water use reports indicate 340 mgd was diverted in 2014, while the historic annual average flow for EMI was 160 mgd according to the 2004 AWUDP. The 2014 reported flow (347 mgd) is thought to be high due to double counting of gaged flows in the ditch compared with an average water use rate of 5,555 mgd per acre for sugarcane stated by HC&S (194.5 mgd applied to the 35,000 acre holding).¹⁰⁰ In addition 2014 exhibited a strong El Nino with higher than normal rainfall in the dry season. Therefore the reported data in Table 8-21 is *not* used as basis to determine used and potentially available surface water.

Table 8-21 Major Diverters, 2014 (mgd)

Diversion Owner	2014 AD	Adjustments	Adjusted 2014
Wailuku Water Co	42.709		42.709
HC&S (EMI)	347.589	exclude 6.62 mgd to MDWS	340.969
Maui Land & Pine	13.262	exclude 3.299 mgd to MDWS	9.963
Other Irrigation	3.917	landscape and resorts	3.917
DWS Surface Water	9.919	surface water treatment (Kula Ag Park nonpotable – 0.12 mgd)	9.919
Total	417.396		407.477

CWRM Monthly Use Reports 2014; MDWS 2014 production data. Numbers may not add due to rounding.

Ground and Surface Water Use

Ground and surface water use and availability on an island-wide basis is summarized in the tables below. Untapped groundwater is the difference between 2014 average daily pumpage and sustainable yield. Diverted surface water, excluding estimated double counted gages, is summarized below. Additional available flow exceeding base flow is undetermined. Diversions prior to 1990 were reported at 333 mgd island wide, and between 2009 – 2015 175 – 247 mgd. On average 113 – 167 mgd is used by EMI/HC&S. Wailuku Water Company reported using up to 76.5 mgd from Na Wai 'Eha including HC&S.¹⁰¹ About 20 mgd of surface water is used in West Maui. Since Na Wai 'Eha base flow (Q_{50}) is 69.5 mgd, it is assumed that diversions should not exceed 69.5 mgd, for an approximate adjusted total of about 270 mgd of total surface water use.¹⁰² Average surface water use is less useful to determine resource adequacy as drought and storm flow are limiting factors for reliability and storage opportunities. The summaries and pie chart below should be considered as estimates with high seasonal variation.

¹⁰⁰ The HDOA Irrigation Water Use Guidelines water use rate for drip-irrigated sugarcane is 6,700 gpd/acre. HC&S-35,556 acres of sugarcane are drip irrigated (Maui County Data book, 2014 <http://files.hawaii.gov/dbedt/economic/databook/db2014/section19.pdf>). However, the rate used here is the water use rate stated by HC&S.

¹⁰¹ Petition to Amend the Interim Instream Flow Standards for East Maui Streams Contested Case, Hearing Officer's Proposed FOF, COL, D&O, January 15, 2016, Page 135; Na Wai 'Eha, Wailuku Water Company Opening Statement.

¹⁰² CWRM Na Wai 'Eha CCH, FOF, COL, D&O, June 10, 2010 (CCH-MA06-01).

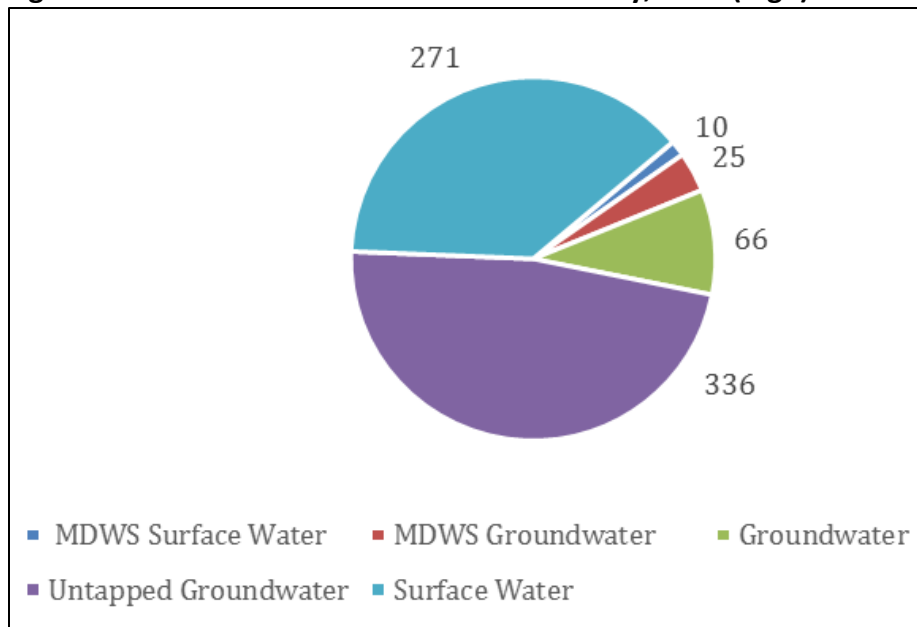
Table 8-22 Ground and Surface Water Use, 2014 Daily Ave (mgd)

Use	Groundwater	Surface Water	Total
Domestic	0.024		0.024
Industrial	0.208	6.660	6.868
Agriculture	57.333	242.088	299.421
Irrigation	4.357	11.073	15.43
Municipal	29.289	10.879	40.168
DWS	25.126	9.919	35.045
Private Public	4.163	0.960	5.123
Total Used	91.211	270.700	361.911
Unused Water	333	Undetermined	

Table 8-23 Resource Availability and Use, 2014 (mgd)

Resource	Available	Used	Balance
GROUNDWATER	427 SY	91	336
Potable Uses		29	
Nonpotable Uses		62	
SURFACE WATER	Undetermined	271	
Potable Uses		11	
Nonpotable Uses		260	
ALTERNATIVE SOURCES	26	3	
Recycled	26	3	23
Other Nonpotable			

Figure 8-10 Water Resource Use and Availability, 2014 (mgd)



Water Transport

The following table characterizes water sources and transports for the Wailuku, Central and Ko'olau aquifer sectors based on CWRM reports and Na Wai 'Eha and East Maui Streams court case documents. Of about 307 mgd used, 222 mgd (72%) was surface water and 85 mgd was groundwater. About 210 mgd was transported to other aquifers, of which 195 mgd was surface water (93%). The chart below shows all ground and surface water discharge by source and aquifer sector area.

Table 8-24 Estimate of Water Sources and Discharges by Aquifer Sector (mgd)

Aquifer Sector	Source	Discharge to Aquifer Sector (Shaded cells – transported from aquifer)				Purveyor - Water Transported From Aquifer Sector		End Use - Water Transported From Aquifer Sector	
		Wailuku	Central	Ko'olau	Total	WWC	EMI	MDWS	HC&S
Wailuku Total	56.10	25.87	27.87	0.00	53.75				
SW	35.33	20.09	12.52		32.61	12.52		1.10	11.42
GW	20.769	5.782	15.35		21.14	15.35		15.35	
Central Total	62.71	0.00	62.71	0.00	62.71				
SW					0.00				182.16
GW	62.708		62.71		62.71				0.02
Ko'olau Total	187.29	0.00	183.18	0.89	184.07				
SW	186.258		182.16		182.16		182.16	6.6	
GW	1.0274		1.02	0.891	1.91		0.02		
Total	306.09	25.87	273.76	0.89	300.53	27.87	182.18	23.05	193.60

Source: CWRM 2014 Well Pumpage and Diversion Data, MDWS 2014 Billing and Production, 2010 Instream Flow Standards CCHMA 06-01-2 D&O.

Water transported within aquifer sectors is not included in purveyor or end use figures. Smaller purveyors and end uses not shown.

Water transport to the MDWS Central and Upcountry Districts is shown in the table below and water transport patterns are shown in the figure below.

Table 8-25 Transport to MDWS Systems, 2014 (mgd)

Purveyor	2014 AD mgd	Aquifer Sector	To MDWS District	Notes
WWC	1.10	Wailuku to Central	Central	Surface water
MDWS	15.35	Wailuku to Central	Central	Groundwater
EMI	6.62	Upcountry	Upcountry	Surface water, potable and Kula Ag Park nonpotable
Total	23.07			7.72 surface water 15.35 groundwater

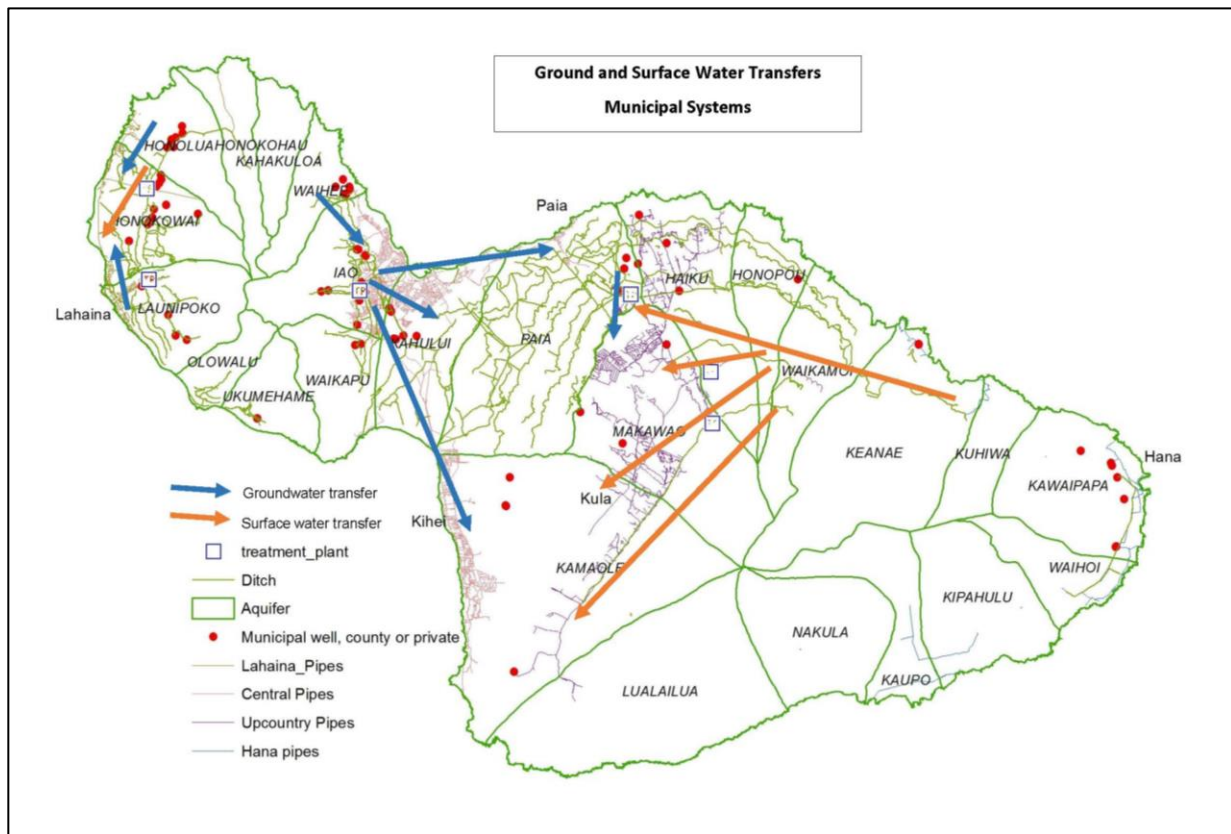


Figure 8-11 Patterns of Water Transfers for Municipal Use

8.2.3 Recycled Wastewater

It is the policy of CWRM to promote the viable and appropriate use of recycled water in so far as it does not compromise beneficial uses of existing water resources. Recycled wastewater is a valuable resource, especially for irrigation purposes. Approximately 2.4 mgd of recycled wastewater is used on the island, primarily for irrigation of agriculture, golf courses and landscape.

On average, more than 12 mgd of recycled water is produced at treatment facilities on Maui, while the design capacity is twice that volume. The reuse of wastewater from the Central Maui, Kihei, Lahaina, and other wastewater systems requires sufficient storage and distribution capability; otherwise, the excess is sent down injection wells. Community and agency concerns over effluent disposal continues to be a primary factor affecting the County of Maui, Wastewater Reclamation Division's (MWWRD) program since most of its wastewater reclamation facilities rely on injection wells. The County is in the process of obtaining NPDES (National Pollutant Discharge and Elimination System) permits to allow injection well discharges.

The State of Hawai'i defines R-1 water as the highest-quality recycled water; it has undergone filtration and disinfection to make it safe for use on lawns, golf courses, parks, and other areas used by people. R-2 recycled water can only be used under restricted circumstances where human contact is minimized. R-1 is primarily used in West and South Maui. R-2 is used in Kahului. The majority of the R-1 and R-2 water use is for irrigation. The Maui County Code was amended in 1996 requiring commercial properties (agricultural, commercial, public uses) within 100 feet of a Maui County R-1 water distribution system to connect within one year of recycled water availability and to utilize recycled water for irrigation purposes. The CWRM can also require dual water supply systems for new commercial and industrial developments in designated water management areas if a non-potable source of water (such as stormwater) is available.

Table 8-26 Wastewater Reclamation Facility Capacity, Production and Use, 2014 (mgd)

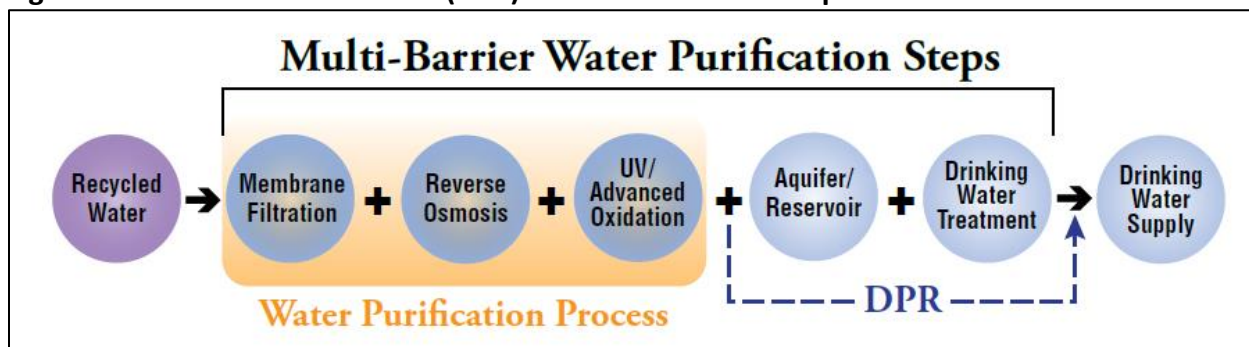
WWRF	Treatment Level	WWRF Design Capacity	Recycled Water Produced	Recycled Water Used	% of Total Produced Used	% of Design Capacity Used	Application
Wailuku-Kahului	R-2	7.9	4.7	0.25	5.3%	3.2%	None
Kihei	R-1	8	3.6	1.5	41.5%	18.7%	Golf Course, Agriculture, Dust Control, Landscape, Fire Protection
Makena (Private)	R-1	0.75	0.08	0.08	10.6%	10.6%	Golf Course
Pukalani (Private)	R-1	0.29	0.19	0.19	100%	65.5%	Landscape
Haleakalā (Private)		N/A	0.18	N/A	N/A	N/A	Closed loop system; Sanitary purposes
Lahaina	R-1	9	3.84	0.88	22.9%	9.8%	Golf Course, Landscape, Nursery, Agriculture
Subtotal		24.9	12.1	2.38			
Total		25.9	12.6	2.65			

Source: County systems: County of Maui Environmental Management Dept., Wastewater Reclamation Division, 2014 Average. Other systems, 2013 Update of the Hawai'i Water Reuse Survey and Report, State of Hawai'i, 2012 data.

Direct potable reuse is another method of using recycled water by introducing highly purified recycled water into the raw water supply immediately upstream of a water treatment plant, or into the distribution system downstream of a water treatment plant. In comparison, indirect potable reuse (IPR) first passes purified water through an environmental buffer such as a groundwater aquifer or reservoir. In all cases, water is treated to drinking water standards prior

to distribution for potable use. Direct potable reuse projects in the U.S. typically blend about five to 50 percent or more purified recycled water with the raw water supply.¹⁰³

Figure 8-12 Direct Potable Reuse (DPR) Water Purification Steps



Water Reuse California, Direct Potable Reuse, Winter 2015-California Legislative Update. DPR- Direct Potable Reuse.

Potential opportunities exist in locations where wastewater reclamation and water treatment facilities are in close proximity, such as in Lahaina or Kihei.

Known constraints or uncertainties may generally include public acceptance, despite proven, existing technologies to treat recycled water to drinking water standards, which would require a robust education and outreach program. Department of Health regulations and rules to allow direct potable reuse are not in place. A County charter amendment to address organizational issues is likely necessary, along with other licensing and administrative issues. Potential modifications to wastewater reclamation facility and water treatment plant and distribution systems may be necessary to accommodate new source water, and back-up disposal for recycled water in the event of excess supply or contingencies would need to be maintained.

8.2.4 Rainwater Catchment

Rainwater catchment is the collection of rainwater from a roof or other surface before it reaches the ground. Rainwater catchment systems are not regulated by the Department of Health, making estimates difficult. Rainwater catchment is not as reliable as conventional water resources because it is extremely sensitive to the climate. Scattered use occurs throughout East Maui where consistent rainfall makes the systems feasible as a domestic source. The only public water system supplied by catchment is the Haleakalā National Park. Household demand unserved by public systems is grossly estimated at about 0.28 mgd including catchment, surface water, etc. No inventory of installed catchment systems throughout the island is available.

¹⁰³ WateReuse California website. <https://watereuse.org/sections/watereuse-california/>
 San Vicente Reservoir augmentation project:
https://www.sandiego.gov/sites/default/files/legacy/water/pdf/purewater/awwajournal_sept2013.pdf

8.2.5 Stormwater Reuse

Stormwater reuse provides for capture and reuse of surface water runoff. Stormwater reclamation can potentially provide water for non-potable water demand such as irrigation and toilets. There are a variety of stormwater technologies as illustrated in the table below ranging from small rainwater catchment systems to reservoir storage systems. Due to contaminants picked up by stormwater runoff, different levels of treatment may be necessary. Water-impounding reservoirs, which are regulated by DLNR's Dam Safety Program, include the Waikamoi and Olinda reservoirs which supply the MDWS Upcountry system. Stormwater reclamation methods that employ capture and storage technologies must be planned, constructed, and operated to ensure minimal impact to streams, riparian environments, conservation lands, water rights, cultural practices, and community lifestyles.

Reduced reliance on groundwater and surface water for landscape irrigation may be appropriate, especially when incorporated into the design of development projects to maximize water retention and minimize infrastructure costs. However, there is no code requirement for development projects to incorporate water retention or reclamation design features for the purpose of supplementing nonpotable water supplies.

Table 8-27 Stormwater Reclamation Technologies

Technology	Description
Source Reuse	Use rain barrels or cisterns to collect precipitation or stormwater runoff at the source to provide water for a variety of non-potable purposes or, with treatment, potable water.
Small Lot Reuse	Manage precipitation or runoff as close to source as feasible. Examples: infiltration planter boxes, vegetated infiltration basins, eco roofs (vegetated roofs), porous pavements, depressed parking lot planter strips for biofiltration, narrowed street sections with parallel or pocket bioswales.
Stormwater Capture	Employ ditches, storm drainage system interception, dry wells, infiltration galleries, and injection wells to capture stormwater.
Stormwater Storage	Use aquifer storage and recovery, stream-bank storage, detention basins, and surface reservoirs to store stormwater.
Stormwater Distribution	Distribute stormwater via gravity ditch or pipe networks, operated/regulated ditch systems, pressure pipe networks, onsite wells.
Source: CH2MHill. <i>Hawaii Stormwater Reclamation Appraisal Report</i> . Prepared for the U.S. Bureau of Reclamation and the State of Hawaii Commission on Water Resource Management. July 2005	

8.2.6 Desalination

Desalination can remove salt and other dissolved minerals from the source water. Seawater, brackish water, or treated wastewater can be processed through several desalination methods:

distillation, vacuum freezing, reverse osmosis and electrodialysis. Brine disposal and cost have posed significant impediments. Desalination is more costly than conventional water resources due to treatment and monitoring requirements, although costs have been decreasing. A cost evaluation for brackish water desalination in Central Maui region and aquifer sector was assessed by Brown & Caldwell in 2013. For an average increased production of 6.85 mgd, total net present value was assessed to about \$9 per 1,000 gallons of desalinated water supply. The energy intensive technology currently available would add freshwater supplies but not provide other environmental co-benefits. Desalination of brackish water is generally more cost-effective and environmentally-friendly than use of sea water. Source water quality is an additional concern for desalinating brackish water. Trace amounts of pesticides have been found in some irrigation wells in the Kahului Aquifer and brackish wells may contain the same pesticides.

9.0 FUTURE WATER NEEDS

The characterization and projection of water demand includes the impacts of past water conservation programs and existing levels of recycled water use. Impacts of future programs and any increases in alternative source water use are not included in the water use projections. These future measures will be characterized and evaluated as potential resource options to meet the projections of water demand.

Land use based water demand is based on water system standards, while population based demand is projected based on actual demand. Applicable water use unit rates from the MDWS 2002 *Water System Standards*, Domestic Consumption Guidelines, are shown below. Adjusted water use rates especially for residential use are based on empirical consumption data.

Table 9-1 MDWS Water System Standards (Average Daily Demand)

Use Categories	2002 Standards	Adjusted Standards
Residential		
Single-Family or Duplex	600 gal/unit or 3000 gal/acre	South Shore: 1,000 gpd North Shore: 600 gpd
Multi-Family Low Rise	560 gal/unit or 5000 gal/acre	
Multi-Family High Rise	560 gal/unit	
Commercial		
Commercial Only	6000 gal/acre	
Commercial/Ind Mix	140 gal/1000 sf	
Commercial/Res Mix	140 gal/1000 sf	
Resort (includes hotel)	350 gal/unit or 17000 gal/acre	
Light Industrial	6000 gal/acre	
Schools, Parks	1700 gal/acre or 60 gal/student	
Agriculture	5000 gal/acre	3,400 gal/acre (AG WUDP)

MDWS 2002 Water System Standards. Adjusted standards based on empirical use or as stated.

9.1 Land Use Based Full Build-Out Water Demand Projections

Maui County Zoning

The Comprehensive Zoning Ordinance sets forth permitted and conditional land uses which support the land use patterns in the MIP and provides a basis for calculating the land use based water demand projections. The MIP and Community Plans also provide guidance for the Project District zones where large development projects are anticipated and for the Interim zone which is primarily planned for open space uses. The zones, acreage, and water use standards which are used as a basis for the land use based water demand projections are shown in the table below. The water use rates for the Project District and Interim zones were assigned based on the guidance in the MIP and Community Plans.

Table 9-2 Use Zone Districts and Water Use Rate, Excluding DHHL Lands

Use Zone Districts	Acres	% of Total	Water Use Rates (gpd per acre)
Single Family R-1, R-2, R-3, Duplex	7,618.33	1.6%	3000
Apartment A-1, A-2	1,209.26	0.3%	5000
Hotel H, H-1, H-M, H-2	804.84	0.2%	17000
Business B-1, B-2, B-3, BR, BCT, SBR	552.52	0.1%	6000
Industrial M-1, M-2, Kihei R&T, Airport AP	3,074.54	0.7%	6000
Agriculture AG	247,590.82	53.4%	3400; sugarcane 5555
Rural 0.5, 1.0	2,794.15	0.6%	3000
Golf Course GC	422.78	0.1%	1700
Public/Quasi Public P, P-1	633.08	0.1%	1700
Park PK, PK-1, 2, 3, 4	2,479.50	0.5%	1700
Project District PD	4,397.75	0.9%	Per use type
Open Space OS, OS-2	1,815.54	0.4%	0
Interim I	190,689.30	41.1%	Per use type
Total	464,082.39	100%	

MDWS, Water Resources & Planning Division based on zoning supplied by Maui County Planning Department, Long Range Planning Division, May 2015. Sugarcane water use rate is 5555 gpd per acre per information from HC&S.

Aggregating zoning consistent with the CWRM categories yields the totals in the table below. Interim and Project District zoned lands are assigned to CWRM categories based on guidance in the MIP and Community Plans and the list of major Development Projects maintained by the Planning Department representing projects that have come to their attention. Agriculture zoning occupies the largest area with approximately 5,640 acres located within the Urban Growth Boundary. Nearly half the land on Maui has an open space equivalent zoning with essentially no water demand as shown below.

Projected demand for full build-out of County zoning districts and DHHL plans is 144 mgd excluding agriculture, or 1,007 mgd including agriculture. DHHL demand is detailed in the next section.

Table 9-3 Projected Water Demand Based on Full Build-out of Zoning Districts and DHHL Plans, by CWRM Category (mgd)

CWRM Categories	County Acres	County Water Demand	DHHL Acres	DHHL Water Demand	Total Demand
Domestic	16,928	67.02	2079 (3850 units)	2.31	69.33
Industrial	1,7328	10.39	218.00	1.308	11.70
Municipal	3,9438	15.74	137.80	0.234	15.97
Agriculture	230,844	860.70	14,017.00	47.66	908.36
Irrigated	1,644	1.72			1.72
Military	-	-	-	-	-
Total	255,90	955.57	14,372.80	51.51	1,007.08
Total excluding Agriculture zoning	24,246	94.87	2,434.8	3.85	144.07

Table prepared by DWS, Water Resources & Planning Division. Maui island zoning supplied by Maui County Planning Department, Long Range Planning Division, May 2015. DHHL acres/units based on DHHL Maui Island Plan and Regional Plans.

Water demand based on per acre standards except DHHL domestic based on residential units plus 0.2 acre commercial rate. Open space zoning/land use not included due to lack of water demand. Irrigated includes Park-Golf Course and Golf Course zoning districts.

State Department of Hawaiian Home Lands (DHHL) Land Use Plans

DHHL projections based on its Maui Island and regional land use plans which are under its land use jurisdiction are summarized in the table below. About 5,000 acres were not assigned to a land use category because future plans are undetermined.

Table 9-4 DHHL Land Use – Maui Island and Regional Plans

CWRM Category	DHHL Land Use Category	Acres	Water Use Rate (gpd)	Projected Water Demand (mgd)
Domestic	Residential	2,000.8 (3,850 Units)	600/unit	2.31
	Commercial	78.2	6,000/acre	0.469
Industrial	Industrial	218	6,000/acre	1.308
Agriculture	Agriculture	14,017.5	3,400/acre	47.66
Irrigated	N/A	0	0	0
Municipal	Community	137.8	1,700/acre	0.234
Military	N/A	0	0	0
N/A	Open Space	10,658	0	0
Total		27,110.30		51.51

Source: DWS, Water Resources & Planning Division, May 2015, based on DHHL Maui Island Plan and Regional Plans.

Open Space DHHL Category includes conservation, cultural protection and similar types. Total Acres excludes 5062.5 acres because future land uses are unknown.

The State Water Projects Plan Update, DHHL, May 2017 Final Report proposes a project based demand of 31.078 mgd including anticipated demand after its planning period to 2031. Since this is less than the full build-out land use based demand of 51.51 mgd and therefore, no adjustments to the full-build-out projection is necessary.

State Water Projects Plan

The land use based projections are compared to those in the State Water Projects Plan (SWPP), which projects future water demand to 2020. The SWPP states that, in general, new housing developments, agriculture irrigation projects, major facilities or major expansions were considered as having a significant impact on water resources. The SWPP was updated in 2017 for DHHL projects only, and therefore DHHL projects have been excluded from the table below.

Table 9-5 SWPP Projected Water Demands by Aquifer Sector (Excludes DHHL Projects) (mgd)

Aquifer Sector Area	2020 Potable Demand	2020 Nonpotable Demand	2020 Total Demand	Unmet Needs to be Met by DWS	Projects with New State Water System	Nonpotable Demand to be Met by Potable Sources
Wailuku	0.327	0.022	0.349	0.349	0	0.022
Lahaina	1.156	1.289	2.445	2.445	0	1.289
Central	0.812	9.947	10.759	4.759	6.000	0.034
Ko'olau	0.008	0.000	0.008	0.008	0	0
Hāna	0.006	0.000	0.006	0.006	0	0
Kahikinui	0.003	0.020	0.023	0.023	0	0
Total	2.312	11.279	13.590	7.590	6.000	1.350

State Water Projects Plan, Hawai'i Water Plan, Volume 4, SWPP for Islands of Lanai/Maui/Moloka'i, 2003. DHHL Water Demands totaling 6.4484 mgd are excluded. Projects with New State Water System- Lower Kula Watershed Project. (DHHL Maui Island Plan Development 07082015.xlsx)

Two major State projects (excluding DHHL projects) which lacked source strategies but planned to utilize County water systems, were identified:

Project	Demand (mgd)	Water Quality
Upcountry Maui Irrigation Project	3.61	Nonpotable
Lahaina Master Plan	2.29	Potable

The SWPP states that the remaining balance of unmet potable and nonpotable demands will be integrated into the County's overall water demand. Unmet demands of 1.0 mgd or greater, which are identified in the Lahaina and Central Aquifer Sector Areas, will be recommended for State source development if County water systems cannot meet projected demand. The land use based full build-out projections take into consideration projects in the SWPP and therefore no adjustments to the projected demand are necessary.

Agricultural Water Use and Development Plan (AWUDP)

The State Department of Agriculture (HDOA) oversees and promotes diversified agriculture and state-owned irrigation systems. The 2004 AWUDP projects demand to 2020 on lands served by major irrigation systems which include the East Maui, West Maui, Maui Land and Pineapple/Pioneer Mill, and Upcountry Maui Irrigation Systems. The AWUDP projected an increased water demand of 3 to 12 mgd on 891 to 3,544 acres of agricultural expansion based on a water use rate of 3,400 gpd per acre (which does not include irrigation system water losses). The projection was based upon population growth, partial replacement of imported produce with locally grown produce, and maintaining farm value growth in diversified agriculture.

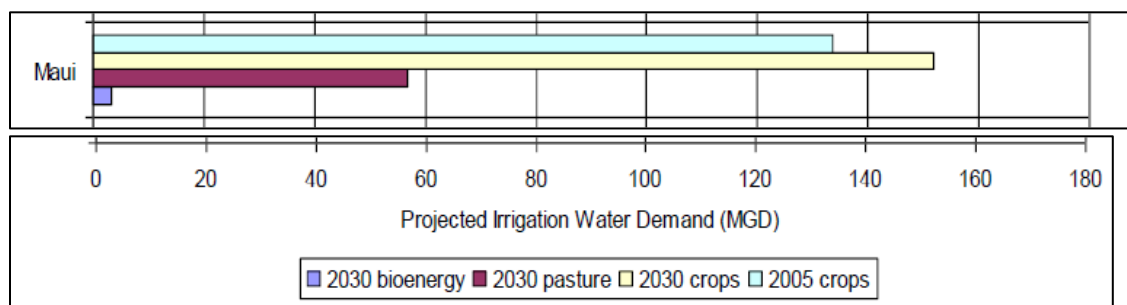
Table 9-6 AWUDP Water Demand Forecast for Diversified Agriculture, 2001-2021

Irrigation System	Total Acres	Acreage in Use		Unused Acreage Remaining Available	Acreage Forecast for Diversified Agriculture		Forecasted Water Demand (mgd)	
		Estimated Percent	Acres		Worst Case	Best Case	Worst Case	Best Case
Pioneer Mill*	3,533	30	1,060	2,473	422	1350	1.43	4.59
Upcountry	1,751	no data	no data	0	55	142	0.19	0.48
East Maui	33,026	70	23,118	9,908	200	1160	0.68	3.94
West Maui	5,400	60	3,240	2,160	214	892	0.73	3.03
Total	43,710		26,358	14,541	891	5,544	3.03	12.05

Compiled by MDWS based on AWUDP, 2003, revised 2004, Tables 6b and 7d. * Does not include Maui Land & Pineapple figures. Water use based on 3400 gpd per acre.

The Hawai'i Department of Agriculture is preparing an update to the AWUDP. Preliminary information provided in 2013 projected an irrigation water demand of an estimated 210 mgd by 2030, which is similar to 2014 demand, with increased demand by the Upcountry and West Maui (Wailuku) Irrigation Systems.¹⁰⁴ The demand forecast did not account for cessation of sugarcane cultivation on Maui.

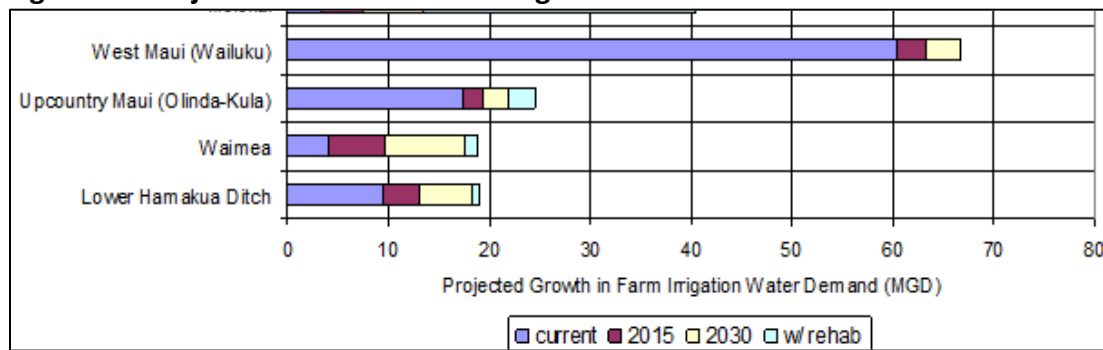
Figure 9-1 2030 Projected Irrigation Demand



¹⁰⁴ Hawai'i Department of Agriculture, AWUDP update presentation, October 23, 2013 Hawai'i Water Works Association Conference.

Source: HDOA, AWUDP update presentation, October 23, 2013 HWWA Conference

Figure 9-2 Projected Growth in Farm Irrigation Water Demand



HDOA, AWUDP update presentation, October 23, 2013 HWWA Conference

The land use full build-out based scenario includes projected water demand for all lands zoned Agriculture and this exceeds the 2004 AWUDP projections and preliminary information above. Therefore no adjustment to the land use based projection is necessary.

Important Agricultural Lands

The State Agricultural District encompasses 242,720 acres or 52% of Maui Island. The 2004 AWUDP indicates there were 67,900 acres of prime agricultural land, with 44,400 acres in monocrop, and 23,400 acres idle on Maui (2001 Statistics of Hawai'i Agriculture). The 2014 Hawai'i Data Book reported that there were 229,166 acres in farms (Maui County 2012) with 35,556 acres in sugar cane (2014). Important Agricultural Lands (IAL) designated by the State comprised 27,294 acres owned by Alexander & Baldwin predominately in sugarcane.¹⁰⁵ There were 149,242 acres of Agricultural Lands of Importance to the State of Hawai'i, ALISH, Prime, Unique, Other. The MIP is most protective of 82,592 acres of important agricultural lands identified by the University of Hawai'i Land Study Bureau, Detailed Land Classification System, LSB - A to C. Since the full-build scenario considers the water demands of land 247,590 acres zoned Agriculture, it encompasses the range of acreage of these land classification systems.

9.2 Population Growth Based Water Demand Projections (20-Year)

The 20-year population growth based demand projections are based on community plan growth rates in the Socio-Economic Forecast allocated to the Aquifer Sector Areas. Projected agricultural water demand is not correlated with population demand and is included as a separate component for a comprehensive assessment of water demands on Maui Island.

Population Forecasts and Water Demand

¹⁰⁵ HDOA, 2/29/16. http://hdoa.hawaii.gov/wp-content/uploads/2013/02/IAL-voluntary-summary-e14_rev2-29-16.pdf

Population is projected to increase island-wide by 31.7 percent from 157,087 in 2015 to 206,884 in 2035, compared to a 33.5 percent increase from 2000 to 2015 according to the updated Socio-Economic Forecast, July 2014, prepared by the Maui County Planning Department, Long Range Planning Division. Population based water demand is projected to increase from an estimated 42.47 mgd in 2015 to 62.5 mgd in 2035, a 47% increase, based on Community Plan growth rates applied to existing demand. In addition to resident population, approximately 16.8 million visitors vacation on Maui each year, an estimated 46,000 visitors a day. The population is aging and household sizes are decreasing. Wailuku-Kahului is expected to remain the most populous Community Plan area, but both Kihei-Makena and West Maui Community Plan areas will have increasing shares of the island population by 2035. DHHL's Maui Island Plan also relies upon the County's growth projections.

The three primary urban centers on Maui, measured by the regional distribution of commercial jobs, are Wailuku-Kahului (44 percent), Kihei-Makena (18 percent), and West Maui (28 percent). Maui County has been dependent on agriculture and tourism, both of which are vulnerable to forces beyond the community's control, and with the cessation of now sugarcane production at the end of 2016, tourism will increase in importance.¹⁰⁶ Slow economic growth is predicted by the 2014 Socio-Economic Forecast which was prepared prior to A&B's announcement. The rates of increase in resident population, housing, and total employment are higher than the rate of growth for visitors. This means the Maui economy has diversified and is less driven by tourism than in the past. With high occupancy rates, construction of new units is expected to resume after 2020, and the supply of visitor units will likely grow at 0.9% or more annually from 2020 to 2040.¹⁰⁷

Population growth rates were assigned to community plan areas by the Planning Department based on assessment of the location of new development projects and project build-out likelihood as an indicator of projected timing. Resident population growth and water demand do not have a direct relationship, but rather are co-related. Several growth related factors complicate predictions of water use, including an increase in the number of visitor accommodations, unoccupied second homes, and transient vacation rentals both legal and illegal in residential areas. Seasonal rainfall anomalies or drought conditions unrelated to population also affect demand.

While the number of residents and visitors (de facto population) in the County on any given day is higher than the number residents alone and more closely reflects water consumption than the number residents alone, resident population is used as the basis for projecting water demand for three major reasons: (1) existing water consumption which is used as a basis for demand projections includes water used by people and economic activities on any given day; (2) existing water consumption reflects the location of water use by occupied residences, visitor accommodations and economic activity on Maui; (3) resident and de facto population are projected to grow at similar rates, with the larger resident population growing at a higher rate

¹⁰⁶ Maui County General Plan 2030 Countywide Policy Plan.

¹⁰⁷ Socio-Economic Forecast, July 2014

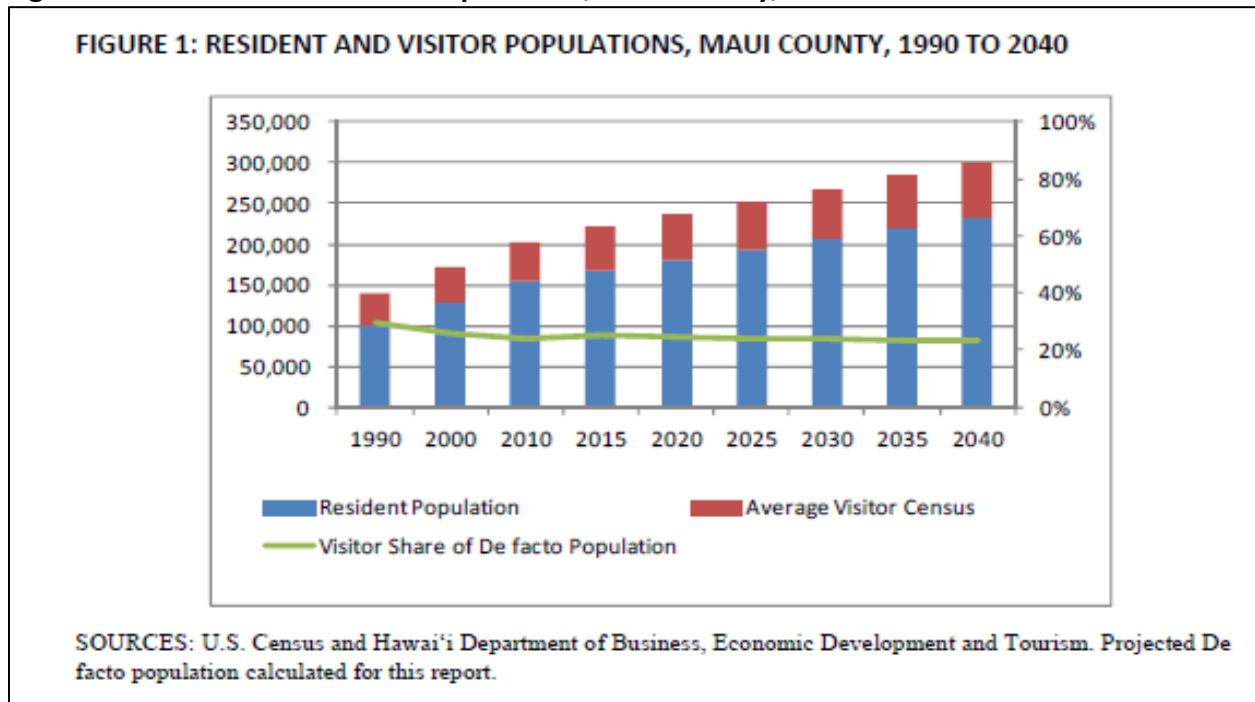
in each area; (4) basing growth on resident population results in a slightly higher projected growth rate in nearly all cases, and , a considerably higher rate in some cases than using defacto population; and (5) the Maui Island Plan projects that the West Maui and Kihei-Makena areas, which have the greatest number of visitors, will continue to expand as visitor destinations, which is consistent with the high population growth rates for these regions.¹⁰⁸

Table 9-7 Community Plan Area Population 1990 – 2035

Forecast Variables	Historical 1990	Historical 2000	Historical 2010	Projected 2015	2020	2025	2030	2035
Population by Region								
West Maui	14,574	17,967	22,156	24,373	27,762	32,318	36,110	39,911
Kihei-Mākena	15,374	22,870	27,244	29,599	34,757	39,975	46,370	52,044
Wailuku-Kahului	32,807	41,503	54,433	60,336	62,102	64,188	65,734	67,986
Makawao-Pukalani-Kula	18,923	21,571	25,198	26,551	28,438	28,949	29,482	29,852
Pa'ia-Ha'ikū	7,788	11,866	13,122	13,820	13,949	14,045	14,139	14,153
Hāna	1,895	1,867	2,291	2,408	2,531	2,660	2,795	2,938
Total	91,361	117,644	144,444	157,087	169,540	182,135	194,630	206,884

Source: Socio-Economic Forecast, 2014 (9/2014), Table R-1 (Refer to report for Table Notes)

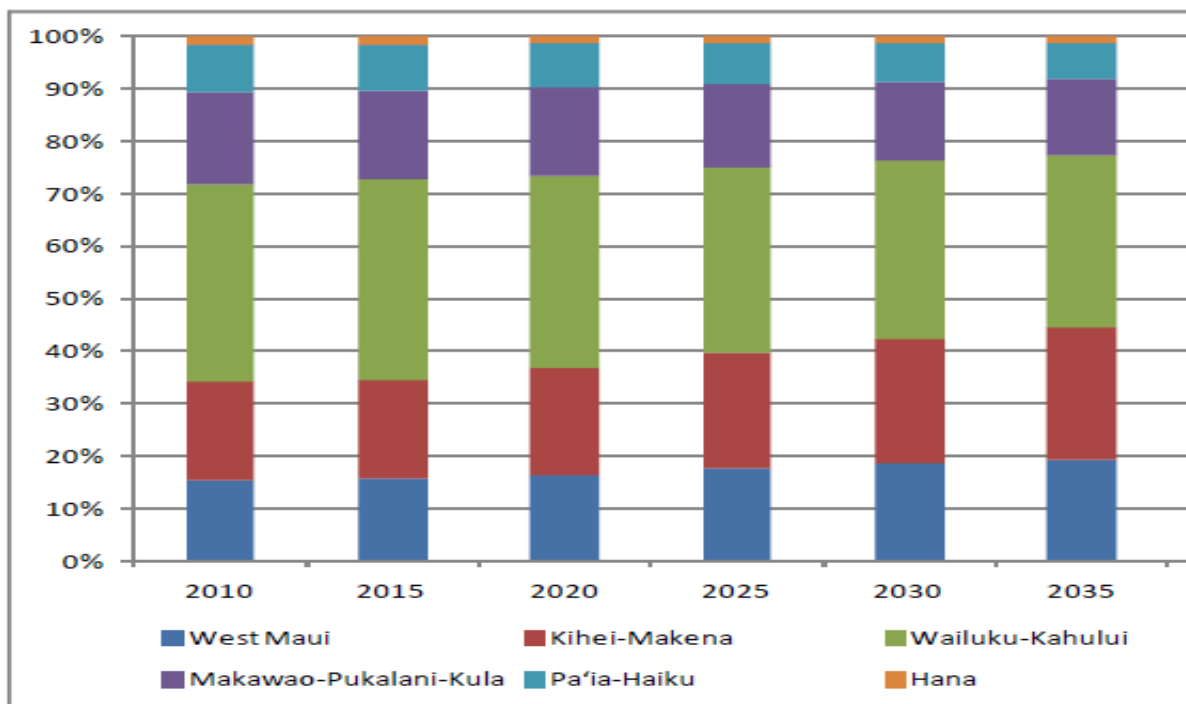
Figure 9–3 Resident and Visitor Populations, Maui County, 1990 to 2040



Maui County Planning Department, Socio-Economic Forecast, 2014, Figure 1

¹⁰⁸ Maui County Planning Department, Socio-Economic Forecast, July 2014

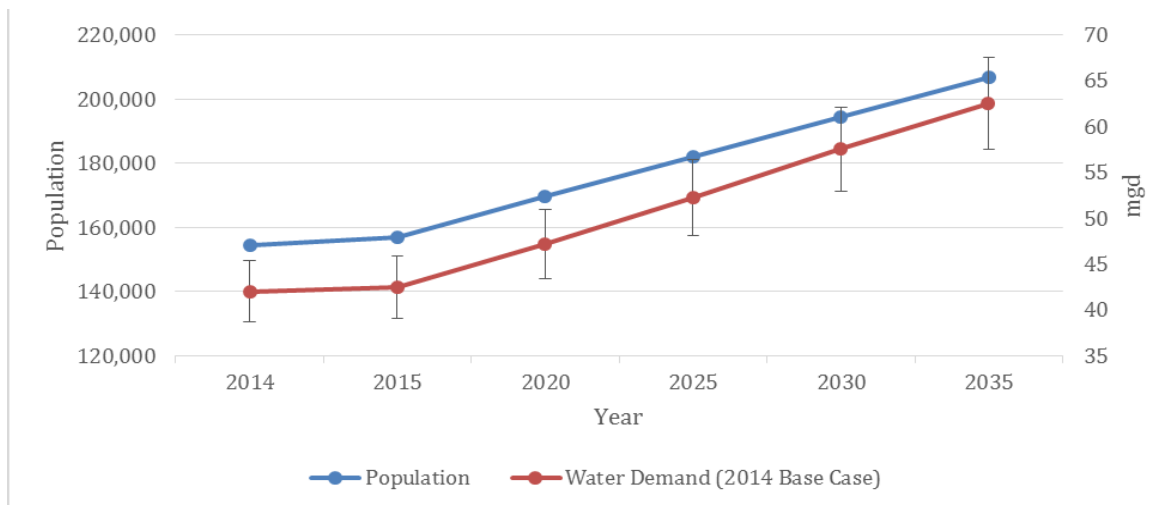
Figure 9-4 Population Distribution on Maui, by Community Plan Area, 2010 – 2035



Socio-Economic Forecast, July 2014

The Socio-Economic Forecast includes high and low population growth alternatives which reflect a margin of error close to 8% above and 8.5% below the base projection, based on the estimated increase from 1990 to 2010 compared to the actual population of the 2010 Census. The projected range of demand to provide a margin of error is about 57 to 68 mgd. The population growth projections and base water demand projection and margin of error is shown in the figure below. It is emphasized that projections should be thought of in terms of a range rather than a specific number.

Figure 9-5 Population Growth and Water Demand with Margin of Error



(Resource Assessment.xlsx)

Population growth based water demand projections to the year 2035 are approximated by Community Plan area and Aquifer Sector Area in the figures below. The largest projected increases are within the Kihei-Makena Community Plan area and the Central Aquifer Sector Area reflecting higher growth rates in the Kihei-Makena area.

Figure 9-6 Population Growth Based Demand by Community Plan Area, 2014- 2035 (mgd)

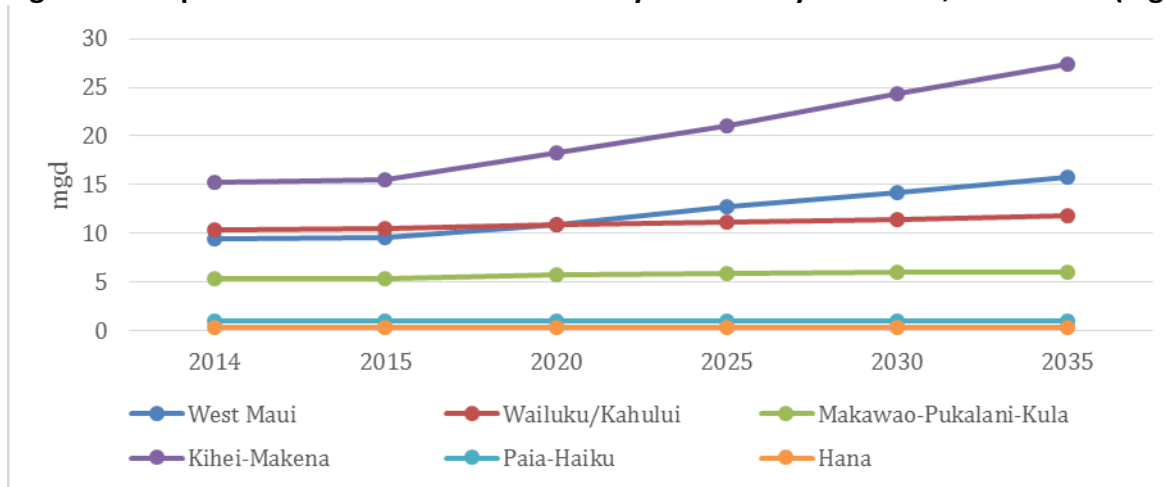
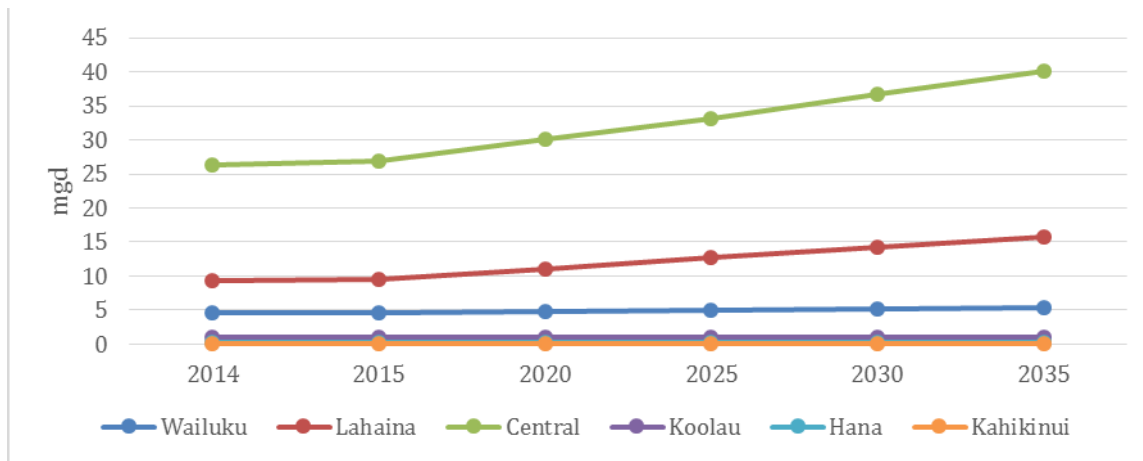


Figure 9-7 Population Growth Based Demand by Aquifer Sector Area, 2014- 2035 (mgd)



Since the population growth rates for community plan areas take into account potential development projects (May 2016) known to the Planning Department, potential water demand for listed projects is based on the water use rates for residential and resort unit demand. Total demand of all projects (excluding commercial, industrial, and public for which water demand would be minimal) is about 21.9 mgd. About 19.7 mgd of demand appears to be within the MDWS service areas, compared to a projected MDWS increase in demand of about 15.5 mgd from 2014 to 2035.¹⁰⁹ It is noted that not all projects may be approved, the number of units may be modified, timing is generally unknown, and it is possible that some projects would use a new private public entity. More information on development projects is provided in the Aquifer Sector Area Reports.

Population growth based demand is compared to the land use based full build-out scenario based on zoning and DHHL land use categories, with and without agriculture. Land use based demand is held constant throughout the planning period.

Table 9-8 Population Growth and Land Use Build-Out Based Water Demand, Maui Island (mgd)

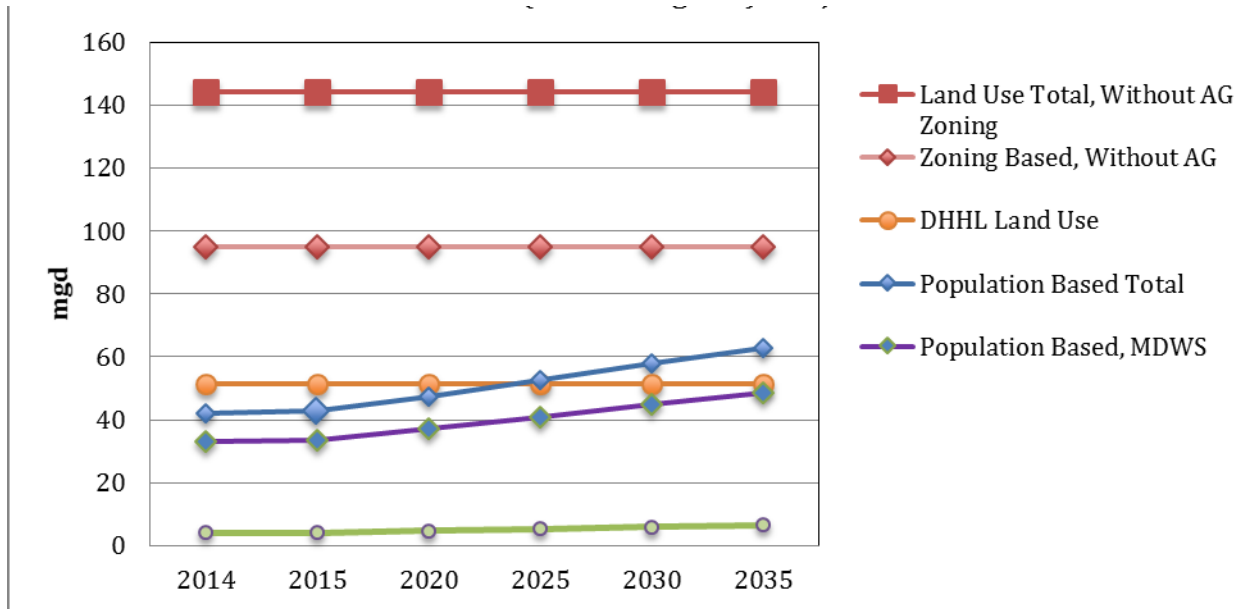
Scenario	2015	2020	2025	2030	2035
Population Growth Based	42.76	47.24	52.55	57.82	62.79
All Public Systems	37.78	42.03	46.51	51.19	55.61
MDWS	33.54	37.16	40.89	44.80	48.50
Other Private Public Systems	4.24	4.79	5.42	6.05	6.65
Other (non-Large Ag)	4.97	5.57	6.24	6.97	7.64
Population Unserved by Public Systems (excludes domestic wells)	0.28	0.28	0.28	0.28	0.28
Land Use Based Without Agriculture Zoning	144.07	144.07	144.07	144.07	144.07
Zoning Based Without AG	94.87	94.87	94.87	94.87	94.87

¹⁰⁹ The large DHHL projects cited in the 2017 SWPP are included on the development project list; Agricultural subdivisions may not be served by public districts.

DHHL Land Use Based	51.51	51.51	51.51	51.51	51.51
Land Use Based Total With AG	1,007.08	1007.08	1,007.08	1,007.08	1,007.08

MDWS based on CWRM Reports, DHHL plans, Maui County Planning Department zoning.

Figure 9-8 Maui Island Population Growth and Land Use Build-Out Based (Excluding AG) Projections



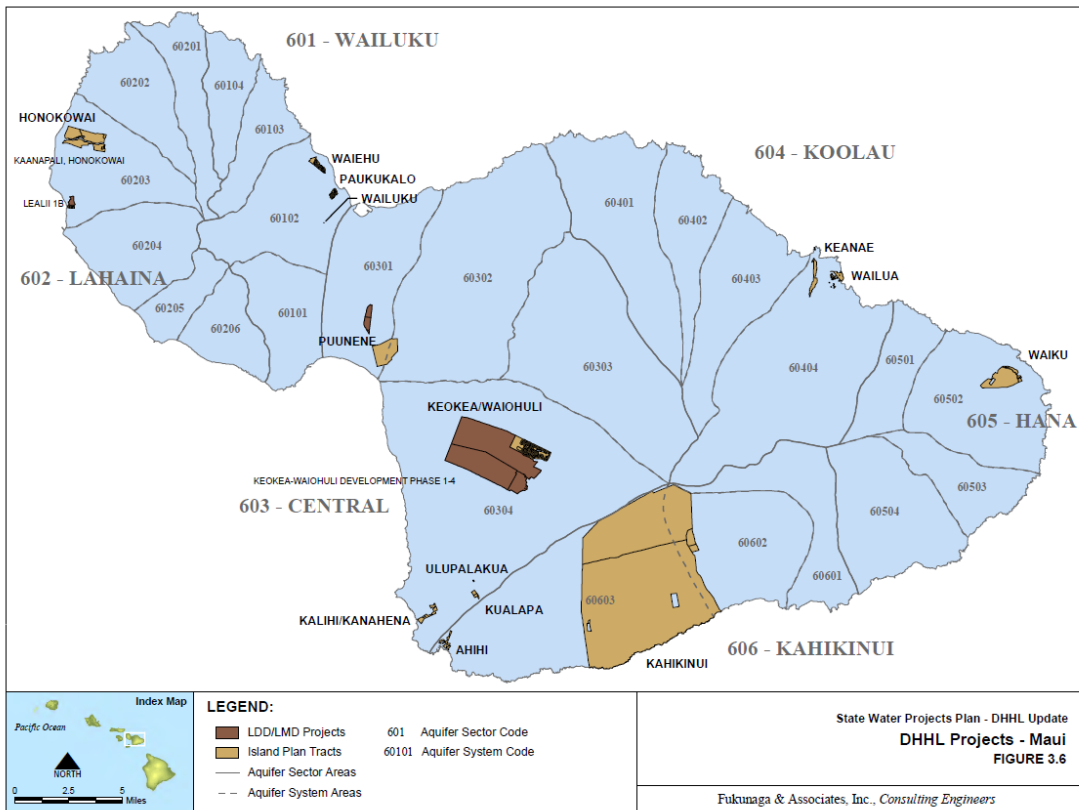
(Sum Maui MUN Pump 2014 Zoning.xlsx)

9.2.1 DHHL Water Demand Projections

The State Water Projects Plan Update, Hawai'i Water Plan, Department of Hawaiian Homelands, May 2017 Final Report provides water use requirement projections for projects shown on the map, planned to be developed below over the 20-year planning horizon from 2015 to 2031. A range of forecasts (high, medium and low) was developed based on prioritization of DHHL needs and uncertainties. Near term priority projects are 1-6 years (2015-2021) and Longer Term priority projects are 7-20 years (2022-2031). Project demands were based on the equivalent County Water System Standards unit rates.

All demands associated with the domestic component of homesteading and municipal use were considered to be potable. Agricultural non-potable demands were based on the diversified agricultural rate of 3,400 gal/acre/day with pastoral use at 20 gal/acre/day. Areas to be developed as lo'i kalo within the Ke'anae and Wailua projects are based on 150,000 gal/acre/day; water demand for lo'i kalo area is subject to change when quantity of available resources are determined. Most General Agriculture nonpotable demands were not included in the nonpotable demand used to develop strategies because these areas may serve as an interim use. Actual water use can vary considerably from planning estimates and strategies do not take into account potential alternate sources of potable and nonpotable water. Additional information on DHHL water demands by hydrologic unit is presented in Appendix 5.

Figure 9–9 DHHL Projects



Projected demand for new projects is 15.173 mgd between 2015 and 2031, with potable demand at 3.551 mgd. An additional 27.557 mgd of nonpotable demand is projected beyond the planning period, for a total of 31.078 mgd.

Table 9-9 Projected DHHL Demands by CWRM Category, 2031 (mgd)

Category	Potable	Nonpotable	Total	Other Nonpotable >2031
Domestic	0.063		0.063	
Industrial	1.824		1.824	
Irrigation			0	
Agriculture		11.652	11.652	27.557
Military			0	
Municipal	1.634		1.634	
Total	3.521	11.652	15.173	27.557

SWPP, May 2017 Final Report, Table 3.9.

Other nonpotable is not expected to be developed by 2031 and strategies were not developed.

Projected demand and strategies to meet that demand are shown in the tables below. DHHL petitioned CWRM in 2015 to reserve groundwater in the Kamaole (est. 1.722 mgd), Kawaipapa,

(est. 0.03 mgd) and Honokowai (est. 0.182 mgd) aquifer system areas.¹¹⁰ If past practices continue, most DHHL projects would be serviced by MDWS systems. There is about 0.0837 mgd of unmet potable need for DHHL projects within or adjacent to the service area of a County water system but without a source option. It is proposed that DHHL would coordinate with Maui DWS to provide services. A large portion of the funding for these projects would be allocated to development of new sources and infrastructure, or towards payment of a proportional cost for new source development and infrastructure expansions and connection to County water systems.

Table 9-10 DHHL Potable and Nonpotable Demand Projections for Maui Island, 2015 to 2031 (mgd)

Primary Use	2015	2016	2021	2026	2031
Potable	0	2.213	2.715	3.457	3.521
<i>Potable Unmet Need- Coordinate with Maui DWS</i>	0	0.0204	0.0323	0.0323	0.0837
Nonpotable	0	1.87	11.397	11.397	11.652
Total	0	4.083	14.112	14.853	15.173
Other Nonpotable (not expected to be developed by 2031)	0	1.87	11.397	11.397	27.557
Grand Total	0	4.083	14.112	14.853	31.078

State Water Projects Plan, May 2017 Final Report, Table 3.6. Cumulative Average Day Demand (MGD).

Table 9-11 Projected Water Demands and Strategies for DHHL Projects, Maui Island, 2035 (mgd)

Sector/ System	Project	Potable	Potable Strategy	Nonpotable	Nonpotable Strategy
Wailuku/ 'Iao	Waiehu	0.017	Coordinate with MDWS (Central) – source not identified	0	
Wailuku/ 'Iao	Paukukalo	0.0034	Coordinate with MDWS (Central) - source not identified	0	
Lahaina/ Honokowai	Honokowai/ Ka'anapali	0.6179	New and/or planned State wells	2.0808	MLP Irrigation System
Lahaina/ Honokowai	Leali'i B	0.1517	New and/or planned State wells		
Central/ Kahului	Pu'unene	1.734	To be determined. Potential transport from Kamole to Kahului Aquifer	1.8564	To be determined

¹¹⁰ CWRM Bulletin, May 2015, Petitions for Reservation of Water 719, 720 and 721.

Sector/ System	Project	Potable	Potable Strategy	Nonpotable	Nonpotable Strategy
Central/ Kamaole	Keokea/ Waiohuli	0.8097	Water Credit Agreement MDWS (0.2810) (Upcountry), New State System (0.5287)	0.578	Upcountry Maui Irrigation System
Central/ Kamaole	Ulapalakua	0.0034	Coordinate with MDWS (Upcountry) – source not identified	0	
Ko'olau/ Ke'anae	Ke'anae	0.0034	Coordinate with MDWS (Hāna) – source not identified	4.5878	Rainfall (0.3128), Pi'inau'u Stream (4.275)*
Ko'olau/ Ke'anae	Wailua	0		2.2802	Rainfall (0.1802), Waiokamilo Stream (2.100)*
Hāna/ Kawaipapa	Wakiu	0.1177	Water Credit Agreement MDWS (Hāna) (0.0612), coordinate with MDWS (Hāna) – source not identified (0.0565)	0.255	Rainfall
Kahikinui/ Lualailua	Kahikinui	0.063	Fog Drip Catchment, truck haul	0.0135	Fog Drip Catchment, truck haul
Total		3.5212		11.6517	

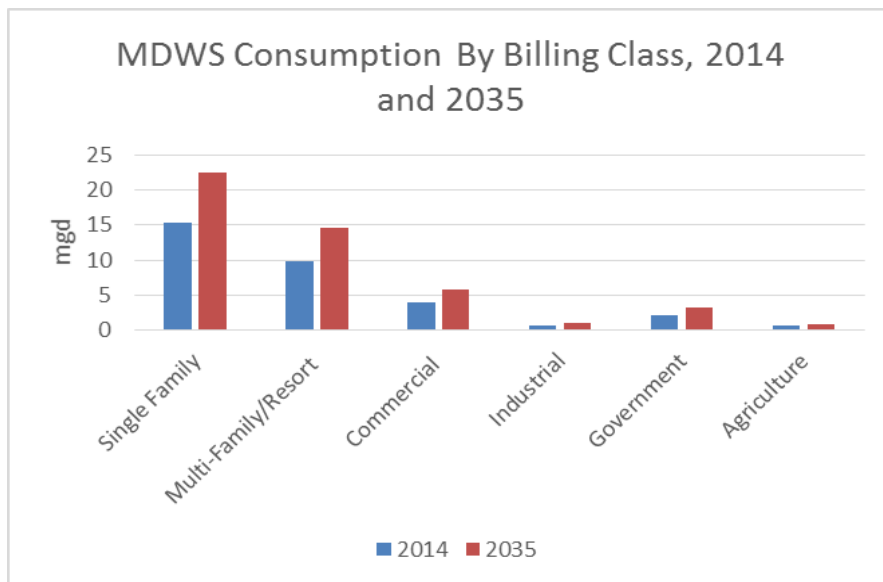
State Water Projects Plan, DHHL, May 2017 Final Report

*Part or all of water demand is based on estimated lo'i kalo area and is subject to change when quantity of available resources are determined

9.2.2 MDWS Water Demand Projections

MDWS projections are based on application of community plan population growth rates in the MIP to 2014 MDWS consumption figures. A 47 percent increase is projected from 2014 to 2035. Projected demand by billing class is shown in the following figure and table.

Figure 9-10 MDWS Consumption by Billing Class



MDWS Billing Classes

Agricultural
Single-Family: Single-Family
Multi-Family/Resort: Multi-Family, Low Rise, High Rise; Housing-County
Mixed Use/Resort: Mixed Use, Hotel, Irrigation- Golf Course-Private
Commercial: Commercial, Religious, School-State/Private, Irrigation- Private
Industrial
Government: City Facility, State Facility, Parks-County/State, Irrigation-State/County, US Military Facility, US Non-Military Facility
Unknown

Table 9-12 MDWS Projected Consumption by Billing Class, 2010 to 2035 (mgd)

YEAR	2010	2014	2015	2020	2025	2030	2035
Maui Island Population	144,444	154,558	157,087	169,540	182,135	194,630	206,884
Single Family	18.096	15.406	16.608	17.372	18.935	20.840	22.570
Multi-Family/Resort	7.784	9.927	10.701	11.194	12.313	13.552	14.677
Commercial	3.389	3.970	4.280	4.477	4.924	5.420	5.869
Industrial	0.994	0.765	0.825	0.863	0.949	1.045	1.131
Government	2.417	2.182	2.352	2.460	2.706	2.978	3.225
Agriculture	1.286	0.657	0.709	0.741	0.815	0.898	0.972
Unknown	0.065	0.052	0.056	0.059	0.065	0.071	0.077
TOTAL	34.031	32.959	33.539	37.160	40.850	44.795	48.503

Source: DWS Billing Data, Calendar Years 2010 and 2014. Maui County Population Projections, Projected Growth Rate from MIP 9-2014 Draft, applied to DWS Consumption figures. Agriculture excludes Kula Ag Park, 0.12 mgd in 2014.

Projected demand by MDWS district indicates the greatest increases will occur in the south (Kihei-Makena) and West Maui areas reflecting high Community Plan population growth rates for those leeward areas.

Table 9-13 MDWS Projected Consumption by District, 2014-2035 (mgd)

MDWS District	2014	2015	2020	2025	2030	2035	% Increase
Central/Wailuku	21.154	21.556	24.025	26.566	29.533	32.294	53%
Upcountry/Makawao	6.263	6.331	6.712	6.824	6.940	7.020	12%
West/Lahaina	5.388	5.496	6.260	7.287	8.141	8.999	67%

East/Hāna	0.155	0.156	0.164	0.172	0.181	0.191	23%
Total	32.959	33.539	37.160	40.850	44.795	48.503	47%

Upcountry Meter List

The Upcountry Meter List of requests for water meters represents a significant unsatisfied demand. As of June 30, 2014 there were 1,822 requests (excluding reservations offered but not accepted, reservations accepted, and meters installed) for an estimated total of 7,284,057 gpd. Historically, about 50 percent of the requests are withdrawn or denied. Projected demand to satisfy the Upcountry meter list is therefore estimated within the range of 3.6 to 7.3 mgd. About two-thirds of the requests are for development that would be located outside the Urban Growth Boundary, while policy in the Maui Island Plan directs urban services to areas within the growth boundaries. As shown below, development of half the meter list could result in a significantly higher water demand than otherwise projected. There remains uncertainty over the number and timing of new meters as well as occupancy (new population, relocation of existing population on Maui, use as vacation or part-time residences). This issue is discussed in more detail in the Central Aquifer Sector Area Report.

Table 9-14 Comparison of Upcountry District with and Without Meter list (mgd)

Criteria	2014	2035	Increase (mgd)
Upcountry/Makawao	6.2	7.0	0.7
Upcountry/Makawao + Meter List	6.2	9.9 – 13.5*	3.6 – 7.3

Assumes 50% - 100% of meter list requests are developed.

Base, Low and High Scenarios

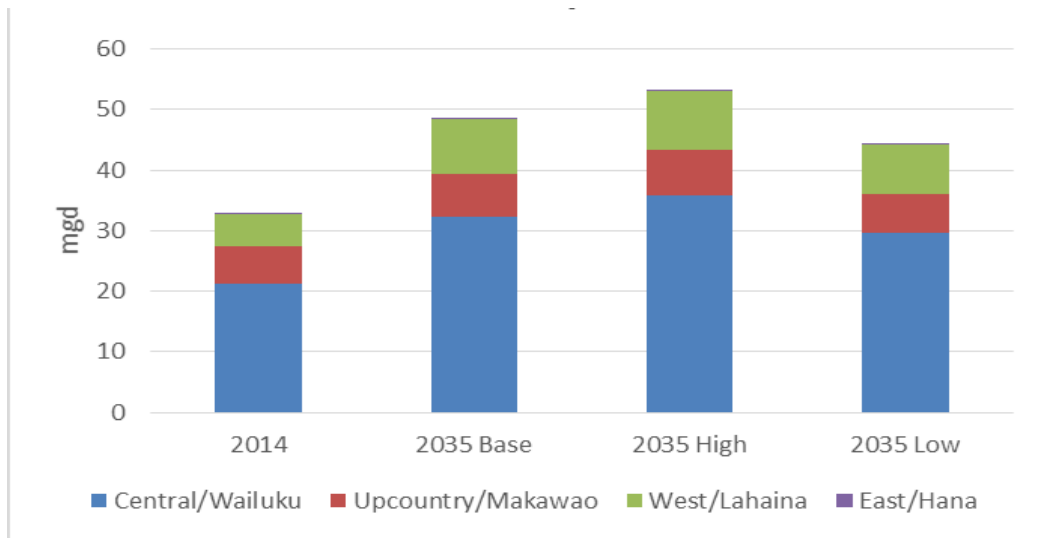
Projected consumption for the base, low and high scenarios indicates the range to be from 48.5 to 53.3 mgd, not taking into account the Upcountry meter list.

Table 9-15 Projected Consumption by MDWS District, Base, High and Low Scenarios (mgd)

District	2014	2035 Base	2035 High	2035 Low
Central/Wailuku	21.154	32.294	35.778	29.533
Upcountry/Makawao	6.263	7.020	7.573	6.420
West/Lahaina	5.388	8.999	9.708	8.229
East/Hāna	0.155	0.191	0.198	0.179
Total	32.959	48.503	53.257	44.361

Excludes Kula Ag Park

Figure 9-11 MDWS Systems, Comparison of Base, High and Low Projections



9.2.3 Privately Owned Public Water Systems Demand Projections

Projected demand is largely based on Community Plan population growth rates. Privately owned public water systems were also queried on the customers, water production capabilities, and future projections but information provided such as service projections were limited in many cases. Since many of the smaller private public systems serve specific development projects, significant increases would not be anticipated. Disclosed information is incorporated. Private public system demand comprises about 12% of the total population based demand.

Table 9-16 Public Water Systems, Population Growth Based Water Demand, Maui Island (mgd)

Purveyor	2015	2020	2025	2030	2035
MDWS	33.54	37.16	40.89	44.80	48.50
Other Private Public Systems	4.24	4.79	5.42	6.05	6.65

MDWS based on CWRM Reports.

9.2.4 Other Population Based Demand Projections

In addition to the public water systems, some persons are not served by public water systems and another component of water use is associated with population and economic demand. An unknown number of persons are not served by any public water system, but rather by wells, catchment and similar means; an estimated 'order of magnitude' demand for 2014 of 0.276 mgd was calculated and is projected to increase at a negligible rate.¹¹¹ Other population based demand includes persons using domestic wells as well as landscape irrigation and industrial

¹¹¹ 2010 Census Block Group populations that appear to be outside public purveyor service areas – approx. 1,190; apply average MDWS per capita rate of 248 gpd based on 2010-2014 consumption and interpolated population = 296,144 gpd. Excluding domestic well pumpage of 243 gpd results an estimated demand of 275,649 gpd.

wells which are not included within public system supplies. Rates of increase are based on the community plan growth rates.

Table 9-17 Other Population Growth Based Water Demand (mgd)

Criteria	2015	2020	2025	2030	2035
Other (non-Large Ag)	4.97	5.57	6.24	6.97	7.64
Population Unserved by Public Systems (excludes domestic wells)	0.28	0.28	0.28	0.28	0.28

MDWS, CWRM Reports.

9.3 Population Growth Based Demand - Agricultural Demand Projections

Agriculture and other large irrigation demands are not included in the population based demand figures above, but should be added to the population based demand figures to provide a complete picture of water use. Incidental gardening, landscape irrigation and small agricultural uses are included with municipal demand or may be represented in lower volume well reports that are incorporated into the demand above. About two percent of MDWS billed consumption is for agricultural use, excluding Kula Agricultural Park which receives nonpotable water.¹¹²

The Hawai'i Department of Agriculture is preparing an update to the AWUDP. Preliminary information provided in 2013 projected an irrigation water demand of about 210 mgd by 2030, which is similar to 2014 demand, with increased demand by the Upcountry and West Maui (Wailuku) Irrigation Systems.¹¹³ While future agricultural activity has the hypothetical potential to increase based on acreages of unutilized agricultural lands, the cessation of sugarcane production is expected to reduce irrigation demand. Despite the interest in food security and self-sufficiency and increasing exports, prospects for substantial increases in agricultural production in other locations are limited. In any case, projected agricultural water demands assume that future agricultural water demand cannot exceed potential agricultural water supply.

To project future water use for agriculture, agricultural activities can be categorized into diversified agriculture and wetland kalo cultivation.

Table 9-18 Water Use Rates for Diversified Agriculture and Lo'i Kalo

Agricultural Activity	Water Use Rate (gpd/acre)	Type of Water Coefficient	Data Source
Diversified Agriculture	2,500 for wetter areas 3,400 for drier areas	Average per acre water use for Diversified Agriculture activities (Does not include irrigation system water losses)	Water demand factor used by the CWRM to calculate potential demand for diversified agriculture in the Waiāhole Ditch Case; the

¹¹² Agricultural use based on billing categories or CWRM categories, which differs from 'Agricultural Services'.

¹¹³ Hawai'i Department of Agriculture, AWUDP update presentation, October 23, 2013 Hawai'i Water Works Association Conference.

Agricultural Activity	Water Use Rate (gpd/acre)	Type of Water Coefficient	Data Source
			State AWUDP uses 3,400 gpd per acre
Lo'i Kalo	100,000 to 300,000 15,000 to 40,000	Per acre water inflow into lo'i kalo system Consumptive use	CWRM Na Wai 'Eha and East Maui Streams Contested Cases

Lo'i Kalo Cultivation

The legal context for Native Hawaiian rights, including Traditional and Customary (T&C) uses, is provided under sections 1.3 and 6.2. Many lo'i kalo are also located in or directly adjacent to the stream, technically within the streambed or high-flow areas and virtually 100 percent of taro water is sourced from streams. However, due to the traditional landscape architecture of the lo'i systems, water utilized for taro is returned to the stream for downstream use with negligible loss. An exception to the downstream reuse of water principle rests in the extent to which other native Hawaiian T&C crops are cultivated by way of irrigation water that is not returned to the stream. Therefore, consumptive use for lo'i taro in terms of unavailable downstream water lost is difficult to quantify but has been estimated at 15,000 to 40,000 gad, although the necessary flow is estimated to be 100,000 to 300,000 gad.

Several methods are used to characterize the potential for lo'i kalo cultivation as well as for vegetables, trees, and plants for subsistence and cultural purposes, as a basis for further discussion and evaluation. The primary data consulted are representations of historical agriculture, kuleana parcels (OHA), CWRM IIFS and contested case documents, the Declarations of Water Use (CWRM), and the 2015 Agricultural Baseline (HDOA). The 1992 Hawai'i Stream Assessment identified stream valley where taro was "truly a part of the large landscape" based on the CWRM Declaration of Water Use certification database, 1989, and adjusted and augmented by the Cultural Resource Committee that worked on the report.

Table 9-19 Landscapes with Significant Taro Cultivation

Streams	Characterization – acres per stream
Waihe'e, Waiehu, Piinaau	> 50 acres
Honokohau, Kahakuloa, Iao, Honopou, Hoolawa, Hanehoi, Waioakamio, Opelu	10-50
Kauaula, Waikapu, Nuaailua, Ohia, Wailuanui, Kawaiopapa, Opelu	Up to 10

Hawai'i Stream Assessment, A Preliminary Appraisal of Hawai'i's Stream Resources, 1992, Report R84, Table 32. Streams and acreages from Declaration of Water Use certification database, 1989 and adjusted and augmented by the Cultural Resource Committee for the report.

Pre-Contact Agriculture

Prediction of the suitability of lands for sustained intensive agriculture pre-contact can be useful to project opportunities for future wet and dryland agriculture. Community members

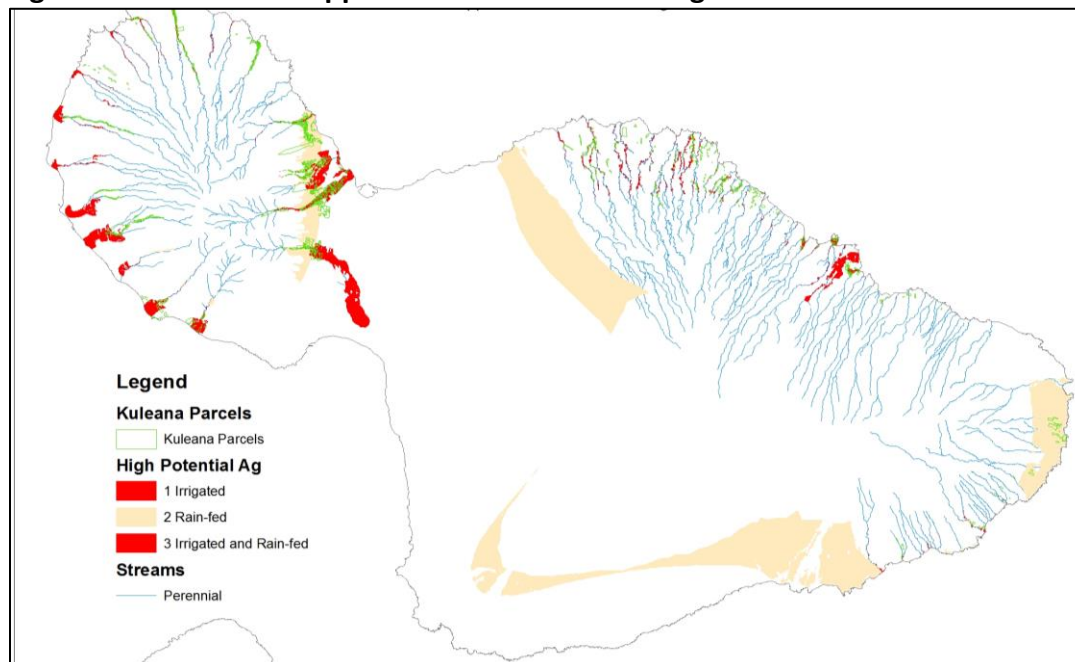
have pointed to pre-contact settlement as an indicator of locations that can support increased population in harmony with local resources, as well as a predictor of future agricultural opportunities. A 2009 study developed models for irrigated and rain-fed systems based on the environmental requirements of the primary crops and the previous archaeological research. The irrigated pondfield model is based on five major variables: water source, elevation, slope, gravitational flow, and geomorphology. The primary source of water for pondfields is continuous perennial streams, although springs and groundwater or stream re-emergence near the coast also supplied water. The GIS model included streams with at least 1 km in length above the 1500 mm rainfall isohyet, considered the minimum to supply a stream with sufficient streamflow to provide a reliable water source to potential pondfields and whether a stream extended to the 3000 mm isohyet, and assumed that the appropriate streams and stream segments could distribute water to areas extending up to 500 m from the stream. The rain-fed agriculture model is based on GIS-derived rainfall and elevation, as well as proxy measures of soil fertility. Predictions for Maui, assuming that all suitable areas cultivated at the end of the pre-contact era, are shown below and on the map (not all acreage is visible at the map scale).

Table 9-20 Predicted acreage of wetland and rain-fed field systems, Pre-Contact Maui Island (acres)

High potential for irrigated agriculture	High potential for rain-fed agriculture	High potential for irrigated and rain-fed agriculture	Total agriculture area
6,360.5	34,436.6	605.4	41,513.7

Ladefoged, T.N., et al., Opportunities and constraints for intensive agriculture in the Hawaiian archipelago prior to European contact, p 8.

Figure 9–12 Predicted Opportunities for Intensive Agriculture in Pre-contact Era



The Nature Conservancy, GIS data, Opportunities and constraints for intensive agriculture in the Hawaiian archipelago prior to European contact

Some of the areas of predicted opportunities for intensive agriculture areas in the Lahaina region are currently developed or within the Urban Growth Boundary. Although difficult to discern at the map scale above, kuleana parcels are often located upstream of the predicted opportunities for intensive agriculture. Two agricultural use scenarios for kuleana parcels by watershed scenarios were developed as shown in Appendix 8. Scenario 1 assumes that 25 or 50 percent of the total acreage of kuleana parcels by watershed would be cultivated for diversified agriculture. Scenario 2 assumes 25 or 50 percent of acreage cultivated for wetland taro calculating consumptive and streamflow needs. The table in Appendix 8 is summarized as follows.

Table 9-21 Scenarios: Potential Cultivation of Kuleana Parcels

Scenario	Standard (gpd/ac)	25% of acres cultivated (mgd)	50% of acres cultivated (mgd)
1: Diversified Ag	3,400	2.8	5.6
2: Wetland Taro - Consumptive Use	15,000-40,000	12.4 - 32.9	24.7 - 65.9
2: Wetland Taro - Streamflow	100,000 - 300,000	82.3 - 247.0	164.7 - 494.0

Kuleana Parcels: OHA data, 2009. MDWS: Calculations.

The results provide a range of potential with the lower end thought to be most realistic in terms of actual land use and availability of water. It is noted that calculating percentage on acreage by watershed overestimates water use compared to calculations on a per parcel basis.

Na Wai 'Eha

Before the 1980s, delivery of water to most kuleana systems occurred only when water was delivered by Wailuku Water Company (WWC) for agricultural operations through the ditches and reservoirs to which the kuleana systems were connected; in the 1980's WWC replaced the ditches with pipes. There were 17 kuleana (or possibly 18) ditch/pipe systems identified at the Na Wai 'Eha Contested Case Hearing; 14 systems are connected to one of the primary distribution systems, and three divert water directly from a stream. In 2005 and 2006, 6.84 mgd was delivered to kuleana system users of Waihe'e, Waiehu, 'Iao and Waikapu Streams. Nearly 50 persons testified at the Contested Case Hearing, involving approximately 135 acres, mostly comprised of small parcels, of which about 45 acres were or were intended to be cultivated, primarily in wetland kalo; but also for vegetables, trees, and plants for subsistence and cultural purposes. Persons who were receiving water testified that the amounts currently delivered were insufficient, especially for the purposes of lo'i kalo cultivation, and nearly all desired to increase their land under cultivation. Most of those not receiving water intended to resume or start cultivation of a portion of their lands. The number of future "kuleana" users beyond those identified at the Contested Case Hearing is unknown. The CWRM concluded that much of the water reported by WWC as being delivered to the kuleana lands is being lost between WWC's source and the kuleana ditches/pipes.

In setting the IIFS for Na Wai 'Eha streams on June 10, 2010, the CWRM concluded that current kuleana lands receive more than 130,000 to 150,000 gad per acre for their kalo lo'i translating to about 260,000 to 300,000 gad when adjusted for the 50 percent of time that no water is needed to flow into the lo'i. These amounts would be sufficient for proper kalo cultivation and even meet *Reppun's* estimate of sufficient flow. Most of this water will flow through the lo'i and into other lo'i or back into the stream and will be available for other uses such as for downstream lo'i complexes and other agricultural uses, or for increased stream flow for improved stream animal habitat. Based on a reasonable consumptive use of 15,000 to 40,000 gad, the net consumptive use by the kalo lo'i would be on the order of 0.68 mgd to 1.71 mgd, with 1.71 mgd more than sufficient for kuleana landowners' kalo, domestic and other agricultural uses.

Table 9-22 Deliveries to Kuleana Systems and Consumptive Use, Na Wai 'Eha 2006 (mgd)

Stream Source	Delivery Amount	Current/Future Consumptive Use – Allowable Diversions
Waihe'e*	5.42 (4.99 + 0.43)	All streams – 1.75 kuleana (Waihe'e – 2 MCLT; potential underlying basal aquifer alternative = 0)
North Waiehu	0.16	
South Waiehu*	0.25	
'lao	0.13	
Waikapu	0.84	
'lao/Waihe'e	0.04	
Total*	6.84	1.71

CWRM 2010 CCH-MA0601-02, Table 2, page 203.

*WWC stated 6.16 mgd delivered; Hui/MTF stated there is an additional 0.43 mgd sourced from Waihe'e Stream; HC&S stated South Waiehu Stream supplied an additional 0.25 mgd.

** 1.71 mgd plus 1.5-2.5 mgd (2 mgd average) for MCLT. Practical alternative for MCLT is underlying basal aquifer.

Because Na Wai 'Eha kuleana users testified that their water deliveries were inadequate, and together with observations of numerous leakages from the ditches, the CWRM concluded that much of the water reported by WWC as being delivered to the kuleana lands is being lost between WWC's source and the kuleana ditches/pipes. Currently, kuleana users served by WWC's system are responsible for maintaining their kuleana system ditches and pipes which produces inconsistent results within different user-maintained systems. Water for lo'i kalo is a non-instream use and must show a lack of practicable mitigating measures for losses. While water must be provided for consumptive lo'i kalo use and flow-through for wetland kalo, there will be large amounts of waste if outflows are not returned downstream of the diversions, as well as disruption of stream flows and possible dewatering in the stretches between the diversion and return points. Even if access to stream water through an 'auwai is part of the customary Hawaiian practice of growing kalo on kuleana lands if practicable measures are available to prevent or minimize waste of the surface water resource, they should be utilized.¹¹⁴ Thus, in order to prevent or minimize waste, kuleana ditches should be lined or enclosed pipes

¹¹⁴ Haw. Rev. Stat. § 1-1, *Reppun*, 65 Haw. at 539, 656 P.2d at 63

used in their place, absent a showing that it is unnecessary to prevent waste, or that it is not practical to do so.¹¹⁵

In a 2014 mediated agreement, restoring additional stream flow to Wailuku River and Waihee Stream was concluded to represent a reasonable and equitable resolution and balance between protecting instream uses and Native Hawaiian practices and accommodating reasonable and beneficial non instream uses, consistent with the public trust.¹¹⁶ The contested case was subsequently reopened and remains ongoing to address the cessation of sugarcane cultivation and change in irrigation demand as an offstream use.

East Maui Streams

The CWRM's May 25, 2010 Commission Order in re the East Maui Streams Contested Case identified the acreage of taro for each stream through the undocumented declarations of registered diverters, as a total of 1,006 acres plus water for domestic needs, but did not attempt to evaluate these claims nor relate these acres to the amount of water added to the streams in the revised IIFS. In amending the IIFS, the estimates of wetland taro and other agricultural requirements, including those that would also qualify for T&C Hawaiian rights, were based on a subset of acreage that Na Moku claimed for appurtenant and riparian rights and demonstrated as suffering actual harm to their owners' reasonable use. In total, the acreage claimed by Na Moku as being either in taro or cultivable agriculture was 136.18 acres for Honopou, Palauhulu, Waiokamilo, and Wailuanui Streams, although Na Moku's expert witness conceded that these acreages are overstated by an unknown amount for taro cultivation and cultivable agriculture.

The CWRM used a water budget for taro of 130,000 to 150,000 gad which translates to an average of 260,000 to 300,000 gad during the time that water is needed to flow into the lo'i to maintain temperatures to prevent rot. Most of this water will flow through the lo'i, and into other lo'i or back into the stream where it will be available for other uses.¹¹⁷

Water Requirements for Taro and Other Agriculture

Area	Stream	Taro Lo'i (acres)	Other Ag (acres)	Taro Lo'i Water Requirements (mgd)	Other Ag Water Requirements (gpd)
Ke'anae	Palauhulu	13.475	7.00	1.75 - 2.02	25,714- 28,571
Wailua	Waiokamilo & Wailuanui	30.160	28.096	3.92- 4.52	13,880 to 16,728
Honopou	Honopou	6.170	9.820	0.80 - 0.93	13,880 to 16,728

¹¹⁵ CWRM's Findings of Fact, Conclusions of Law, and Decision and Order in re 'Iao Ground Water Management Area High-Level Source Water-Use Permit Applications and Petition to Amend Interim Instream Flow Standards Na Wai 'Eha Contested Case Hearing, June 10, 2010 (CCH-MAO6-01).

<http://files.hawaii.gov/dlnr/cwrn/cch/cchma1301/CCHMA1301-20160115-HO-D&O.pdf>

¹¹⁶ <http://files.hawaii.gov/dlnr/cwrn/cch/cchma0601/CCHMA0601-2-CWRM.pdf>

¹¹⁷ Ibid.

The intersection of kuleana parcels and the 2015 Agricultural Baseline indicates that taro and diversified crops cultivated on or partially on kuleana parcels in the Lahaina aquifer sector area totaled about 7.7 acres as shown in the table below. However, given the purpose of the Baseline inventory to capture the scale and diversity of *commercial* agricultural activity in 2015, it is likely that most agriculture on kuleana parcels was not mapped. In the table below, taro is assumed to be wetland taro based on the proximity of the parcels to streams. The midpoint of the range for consumptive water use for wetland taro is used for Estimated Average Water Use. The low and high figures for consumptive water use and streamflow required for healthy plants are also provided.

Table 9-23 Estimated Water Use by Kuleana Parcels per 2015 Agricultural Baseline (gpd/acre)

Aquifer System	2015 Crop Category	Kuleana Parcels Acreage	Water Standard	Est. Ave. Water Use	Consumptive Use		Streamflow	
					Low 15,000	High 40,000	Low 100,000	High 300,000
Honokohau	Taro	3.129	27,500	86,045	46,934	125,156	312,890	938,670
Launiupoko	Taro	0.191 (0.38*50%)	27,500	5,253	2,865	7,640	19,100	57,300
Olowalu	Diversified	4.21 (21.07*20%)	3,400	14,314	--	--	--	--

2015 Agricultural Baseline GIS, Kuleana parcels-OHA, 2009. Approx. ag acreages overlying kuleana parcels calculated by MDWS. Water Use Rates: Diversified Ag-HDOA Guidelines; Taro-CWRM Na Wai Eha and East Maui Streams CCH. Due to proximity of parcels to stream, taro is assumed to be wetland taro. Water standard for taro is average consumptive range of 15,000 to 40,000.

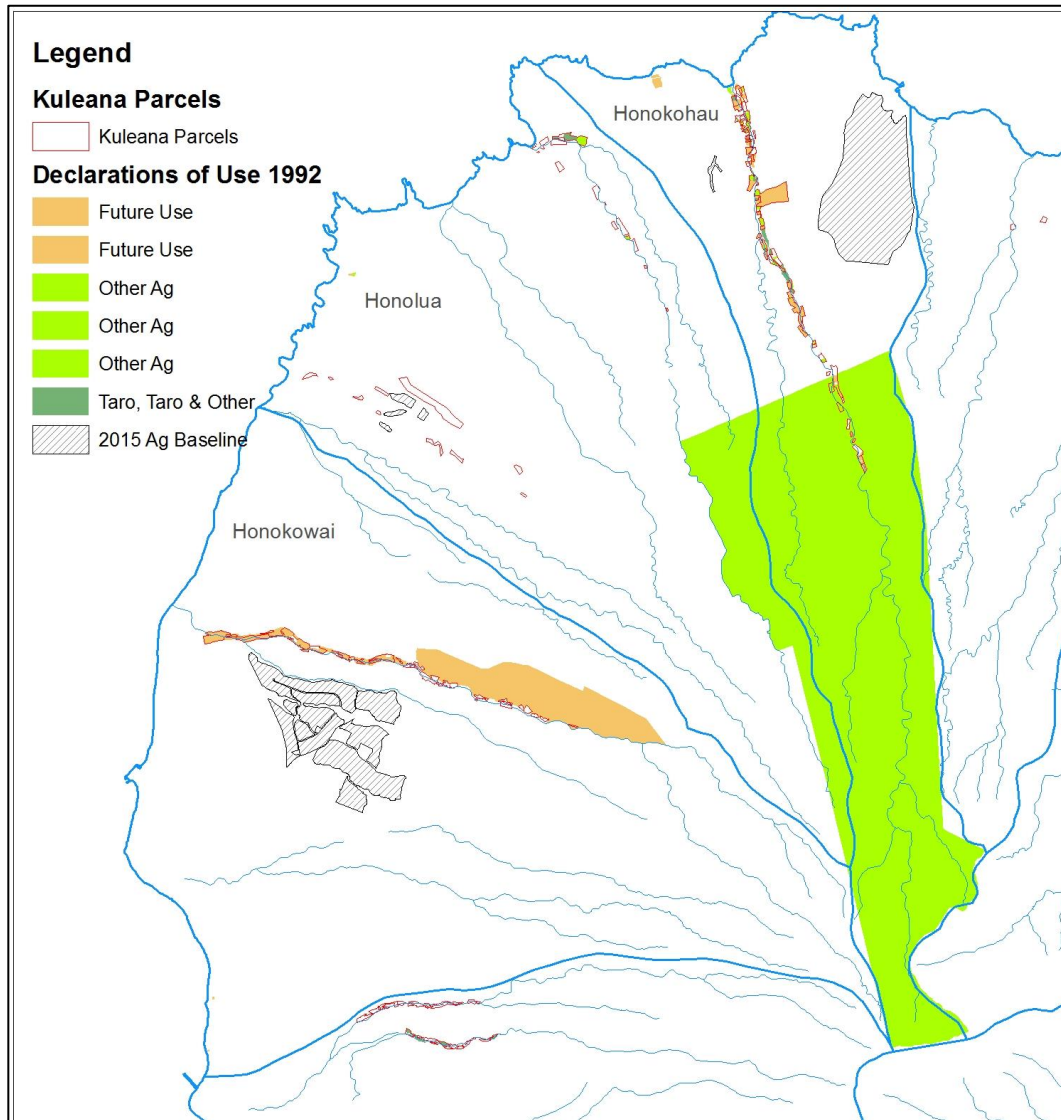
Section 19 provides details of watersheds and streams associated with kuleana parcels, declarations of water use correlated with CWRM diversions, the 2015 Agricultural Baseline, and Predicted Opportunities for Intensive Agriculture in the Pre-contact Era (1- Stream irrigated or 3- Rain and Stream irrigated) described earlier in this section.

The figures below show the relationship of agricultural use stated in the Declarations of Water Use to kuleana parcels. For this analysis, the stated existing uses were categorized as "taro, taro and other," "other agriculture" (excluding grazing), or "future use" including parcels with only rights claims or incomplete information regarding an existing use. Declarations are mapped by TMK, while declaration of use acreages in the table above are those stated in the declarations. Thus, the depictions of Declarations of Use on the following figures are often significantly larger than the acreage stated in the table.

While difficult to see at the scale of the figures below, a significant number of kuleana parcels exhibit a declaration of use for either an existing or future use. The identification of lands where declarants state a rights claim for a future use is provided solely to characterize the locations and scale of potential future uses, recognizing that identification in the plan does not create any legal basis for use or guarantee that a beneficial use will actually occur.

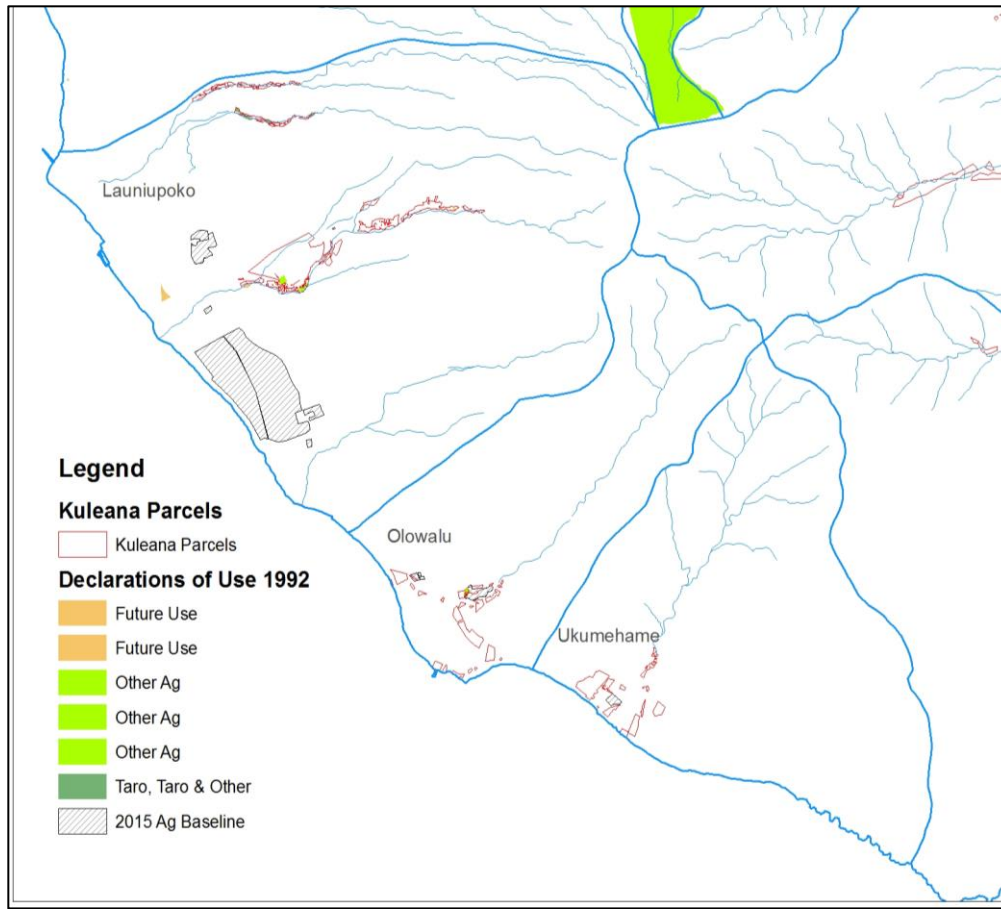
Applying standard water use rates, total demand for land uses in the Declarations of Water Use is close to 0.5 mgd based on the stated assumptions. Given that much of the 2015 Agricultural Baseline inventory is not coterminous with the declarations, the declarations appear to represent an additional increment of agricultural water use.

Figure 9–13a Lahaina Aquifer Systems (Northern) Declarations of Water Use, Kuleana Parcels, and 2015 Ag Baseline



Based on CWRM, Declarations of Water Use, Circular 123, Volumes 1 and 2, September 1992. Information is not verified. Note: Duplication of Future Use and Other Ag in the Legend has no meaning; 2015 Ag Baseline: HDOA

Figure 9–13b Lahaina Aquifer Systems (Southern) Declarations of Water Use, Kuleana Parcels, and 2015 Ag Baseline



Based on CWRM, Declarations of Water Use, Circular 123, Volumes 1 and 2, September 1992. Information is not verified. Note: Duplication of Future Use and Other Ag in the Legend has no meaning; 2015 Ag Baseline: HDOA

Irrigation water for commercial agriculture, excluding kuleana uses, is mainly supplied by surface water conveyed by the Maui Land & Pineapple (ML&P) and Pioneer Mill ditch systems, which is occasionally augmented with ground water from wells. However, CWRM pumpage reports indicate there was essentially no water pumped by agricultural production wells in 2014.

Surface water diversion data reported to CWRM indicates that on average more than 18 mgd was diverted in recent years from streams in the Lahaina region. It is unknown how much of this water is used for agriculture, and not all diversions are reported. Surface water diverted by ML&P has been primarily used to irrigate small-scale diversified agricultural lots, for raising livestock, as well as for golf courses, domestic water supply, and supporting reforestation efforts. Discounting water used for municipal, landscape irrigation and similar uses, it is estimated that roughly 2 to 4 mgd may be used for agriculture. West Maui Land Co. indicates that about 1 mgd is released back to the streams for "cultural" uses.¹¹⁸

¹¹⁸ Dave Minami, West Maui Land Co, personal communication, 2016.

Table 9-24 Surface Water Diversions (mgd)

Gage	Diversion	Period
19 Launiupoko	0.405	2011-2015
20 Kahoma	0.416	2011-2015
21 Kauaula	2.610	2011-2015, 4 mo no data
22 Olowalu	1.622	2011-2015, 7 mo no data
39 Kapalua Water Irrigation	*1.094	2011-2013; no data 2014 -15
40 MLP Troon (Golf)	*0.914	2011-Feb 2014, 3 mo no data
41 MLP Agricultural Irrigation	*0.425	2011-Feb 2014, 3 mo no data
42 DWS Mahinahina	*1.718	2011-Feb 2014, 3 mo no data
43 Ka'anapali Development Co.	*5.450	2011-Feb 2014, 3 mo no data
82 MLP #1 Intake Honokohau (MDWS Operator)	13.540	Mar 2014-Apr 2015
DWS Kanha Intake (Lahaina Treatment Plant)	1.6216	2011-2015
Total	20.214	

CWRM Reports.

*End use accounted for in 6-82: MLP #1. Not double counted in total.

The Statewide 2015 Agricultural Land Use Baseline indicates that coffee crops encompass 535 acres, or 82% of total West Maui cropland, while all other crops comprise only 116.5 acres. Pasture land totals an additional 1096.5 acres. Current water demand based on the stated water use standards in the table below is 2.3 mgd. Based on a hypothetical increase in acreage for the crops in the Crop Summary of one percent annually, agricultural water demand over the next 20 years equates to 2.8 mgd, an increase of less than 0.5 mgd over current estimated demand as shown below. While pasture land is not currently irrigated, it is possible that more intensive use such as for grass-fed livestock would merit irrigation. However due to the speculative nature, such demand is not included in the projection of water use.

Table 9-25 Estimated and Projected Agricultural Water Use, Lahaina Sector (mgd)

Aquifer System	Crop Category	Est. Acreage	Water Standard (gpd)	Est. Ave. Water Use	20% Increase In Water Demand
Honokohau	Taro	3.13	27500 (15-40K)	0.0860	0.1033
Honokohau	Diversified	6.41	3400	0.0218	0.0262
Honokohau	Pasture	630.77	0 (0-7400)	0.0000	0.0000
Honokohau		640.31		0.1078	0.1294
Honokowai	Coffee	534.77	2900	1.5508	1.8610
Honolua	Diversified	19.33	3400	0.0657	0.0789
Honolua	Tropical Fruits	4.15	10000 (3700-10K)	0.0415	0.0498
Honolua		23.48		0.1072	0.1287
Launiupoko	FFL	13.88	6000 (4000-6000)	0.0833	0.0999
Launiupoko	Diversified	12.04	3400	0.0409	0.0491

Launiupoko	Taro	0.38	27500 (15-40K)	0.0105	0.0126
Launiupoko	Tropical Fruits	30.04	10000 (3700-10K)	0.3004	0.3605
Launiupoko	Pasture	465.72	0 (0-7400)	0.0000	0.0000
Launiupoko		522.07		0.4350	0.5220
Olowalu	Diversified	21.07	3400	0.0717	0.0860
Ukumehame	FFL	7.10	6000 (4000-6000)	0.0420	0.0504
Total		1748.81		2.3154	2.7743

2015 Ag Baseline GIS, acreages calculated by MDWS. It is not specified whether taro is dryland or wetland.

FFL=Flowers, Foliage, Landscape

Water Use Rates: HDOA Guidelines; Est Water Use for taro: average wetland taro consumptive rate.

Coffee: 2004 AWUDP Kaua'i Irrigation System- 2500 gpd; 2900 gpd reported by plantation on Oahu per Brian Kau, HDOA, personal communication 10/12/2016.

DHHL Lands

The State Water Projects Plan, DHHL, May 2017 Final Report indicates that nonpotable water demand for agricultural uses for planned DHHL projects is projected at 11.652 mgd by 2031, with an additional demand exceeding 27 mgd in the longer term. Nonpotable is proposed to be met by streamflow, rainfall, and the Upcountry and MLP irrigation systems.

Table 9-26 DHHL Potable and Nonpotable Demand Projections, Maui Island, 2015 to 2031

Primary Use (mgd)	2015	2016	2021	2026	2031
Nonpotable	0	1.87	11.397	11.397	11.652
Other Nonpotable (not expected to be developed by 2031)	0	1.87	11.397	11.397	27.557
Grand Total	0	4.083	14.112	14.853	31.078

State Water Projects Plan, DHHL, May 2017 Final Report, Tables 3.6 and 4.7. Cumulative Average Day Demand (mgd).

HC&S Lands

The HC&S plantation consists of over 43,000 acres of land, of which 35,000 acres were under cultivation in 2016. With the transition from sugarcane cultivation to alternative crops and uses, there are many uncertainties regarding the future of HC&S acreage, existing plantation irrigation systems and water rights. Legal conflicts are mainly focused on competing interests, including the current high demand for water from all types of users, the establishment of instream flow standards (IFS) and the growing concern over native Hawaiian water rights.¹¹⁹ HC&S lands are all located within the Central Sector, the majority of land overlying the Pa'ia aquifer. Surface water used for irrigation is imported from the Ko'olau sector. Yield from irrigation wells in Pa'ia and Kahului aquifers are heavily dependent on return flow from the

¹¹⁹ Maui Island Plan

imported surface water land application and reservoir leakage, although the additional recharge has not been quantified.

HC&S's conceptual "Diversified Agricultural Plan", dated March 2016, illustrates a mix of uses throughout the entire plantation envisioned by HC&S as sustainable and economically viable and takes into consideration soil types, rainfall, solar radiation and crop tolerance to brackish water irrigation.¹²⁰ The information provided in HC&S's plan is presented as planning Scenario 1 in the table below and compared to alternative possible scenarios that were developed with input from the Maui farming community, consulting the State Department of Agriculture, the Hawai'i Agriculture Research Center and island specific publications. On Maui, 27,294 acres were designated by the State and approved by the voters in 2009 as Important Agricultural Lands (IAL), comprised of lands owned by Alexander & Baldwin predominately in sugarcane.¹²¹ Agricultural experts opine that replacement crops will most likely be confined to IAL lands.

An infinite range and combination of alternative crops is possible. For purposes of assessing potential water demand on HC&S lands, crops are grouped into five main categories: 1) Diversified crops; 2) Irrigated Pasture; 3) Biofuel; 4) Monocrops and 5) Forestry. Except for HC&S' Diversified Agriculture Plan (Alternative 1), no assumptions were made about locations for specific crops within the plantation. However, available acreage was considered for crops restricted by elevation, such as koa forestry, or rainfall. Irrigation needs are estimated based on available standards and studies. HC&S irrigation estimates account for site-specific information such as soils, elevation, ET loss and rainfall. Water demand varies significantly depending on cultivation methods. Water loss through various irrigation systems and other efficiencies are not included in this analysis but addressed under Agricultural Conservation Strategies Section 12.2 and water source adequacy for the Central ASEA Section 15.7.

As a baseline comparison, applying a sugarcane water use rate of 5,555 gpd per acre to 35,000 acres equals 194 mgd. Alternative crops and uses would generally represent a reduction in total water use for the plantation.

Diversified Crops: For planning purposes diversified crops is used here to mean farming a variety of crops, such as various orchards and vegetable crops, rather than a single commodity. Community and grassroots initiatives have advocated more opportunities for organic and regenerative farming and an increase in crops for local consumption, including the Shaka Movement, the Organic Farmland Initiative, the report *Malama Aina: A Conversation about Maui's Farming Future* among others. Based on consultation with the agricultural community and DOA, cultivation of diversified crops on 100% of IAL is unrealistic due to labor costs, foreign competition and local market penetration. Irrigation demand varies widely. A range of 2,500 for wetter areas to 5,387 gpd per acre for drier areas is used, which incorporates HC&S

¹²⁰ Case No. CCH-MA13-01 Hawaiian Commercial and Sugar Company's Opening Brief Regarding Re-Opened Evidentiary Hearing; Certificate of Service, October 17, 2016

¹²¹ HDOA, 2/29/16. http://hdoa.hawaii.gov/wp-content/uploads/2013/02/IAL-voluntary-summary-e14_rev2-29-16.pdf

irrigation estimates for orchard crops. Average use for diversified crops according to the 2004 Agricultural Water Use and Development Plan is 3,400 gpd per acre.

Pasture: Conversion to irrigated and non-irrigated pastures for grass fed beef is currently being assessed on less than 400 acres. In the planning scenarios below 1000 – 3440 acres of irrigated pasture were considered and non-irrigated pastures in the Hamakuapoko region of the plantation with more rainfall. Irrigated demand is estimated by HC&S at 1,992 gpd and as high as 2,651 gpd per acre in a study of 5,580 acres in Upcountry Maui.¹²²

Biofuel: HC&S's Diversified Agriculture Plan calls for a mix of bioenergy crops that will be rotated over a few seasons. A variety of crops may include annual seed crops, such as soybean, safflower, sunflower and canola, perennial oil bearing trees, such as jatropha, kukui and pongamia; and tropical grasses, such as energy canes, banagrass, sorghum, hemp and new hybridized perennial tropical grasses. Anticipated focus for 3,650 acres that comprise the Waihe'e-Hopoi Fields are on tropical grasses. Exploratory sorghum plantings are currently underway. Crop and harvest trials on different varieties of energy crops and irrigation needs are tested on a 50-acre trial field planned to expand on an additional 500 acres in 2016. Estimated water requirements for tropical grasses, such as energycanes and banagrass were assessed as approximately 80 to 85% of irrigation needs for conventional sugarcane. A 2011 paper exploring water for biomass-based energy on Maui estimated irrigation needs for jatropha, oil palm and banagrass ranging from 4.9 to 6.5 acre-feet, or 4,372 to 5,799 gpd per acre.¹²³ (HC&S field studies assess water needs for bioenergy tropical grasses at between 4,776 to 5,064 gpd per acre. The irrigation scenarios for sorghum in the 2013 study used 2,977 gpd per acre. For planning purposes, a range representing low irrigation demand sorghum to high water demanding banagrass is applied.

Monocrops: Monocrops are cultivated crops that do not rotate with other crops, such as the former sugarcane and pineapple plantations. Pineapple, coffee and seed production are the largest monocrops currently grown on Maui. Seed crops are currently grown on 754 acres island wide, a portion within IAL. Seed corn accounts for 95% of seed crop grown in the state. Seed crops are generally not land intensive but grown on plots of 1 to 5 acres at a time surrounded by a buffer zone. Expansion of seed crops would therefore not likely account for significant irrigation demand. Irrigation demands for pineapple and coffee range from 1,350 to 2,900 gpd per acre.

Forestry: Former sugarcane lands have been productive for koa forestry where koa seed stock has been selected for disease resistance and adapted to low-elevation sites from 500 feet. Successful forestation would require ripping to break hard pans and allow roots to penetrate. Water requirements estimated at 4,380 gpd per acre vary widely dependent on natural rainfall

¹²² Carey W. King, Ph. D., A Systems Approach for Investigating Water, Energy, and Food Scenarios in East -Central Maui. University of Texas at Austin, November 2013.

¹²³ Grubert, King and Webber, Water for Biomass-based Energy on Maui, Hawai'i, 2011, http://www.academia.edu/1645956/Water_for_Biomass-based_Energy_on_Maui_Hawai'i

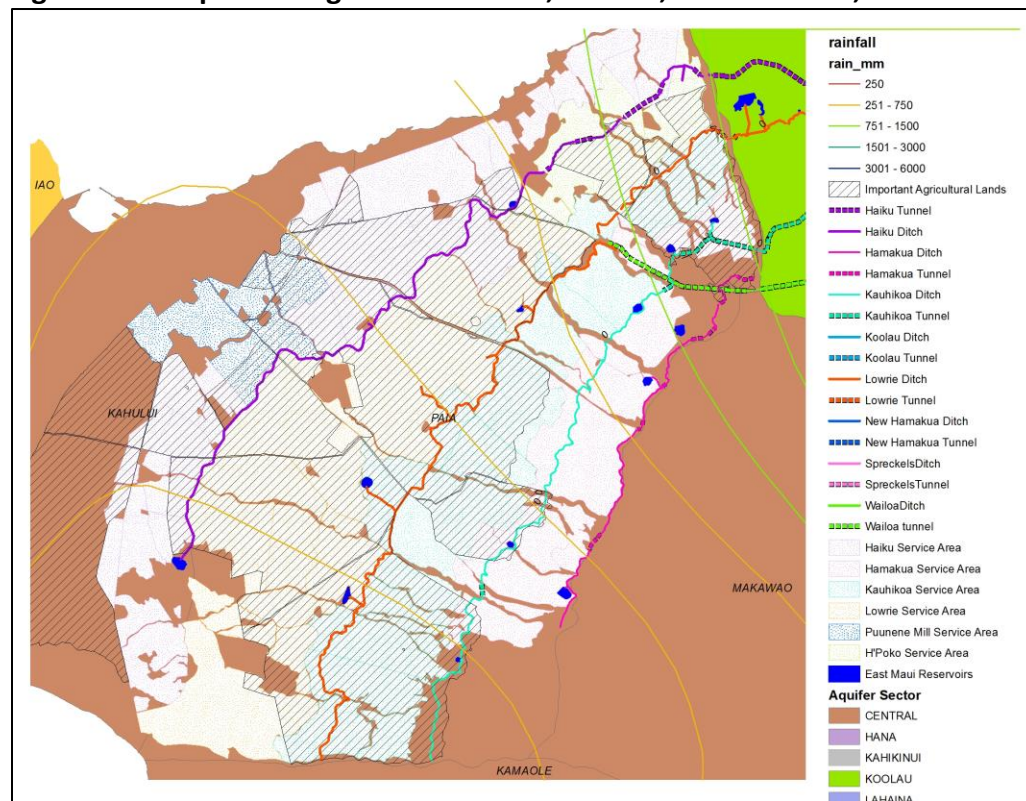
and growth. Other high value timber species, including milo, kamani and sandalwood could be considered for commercial plantings as well as windbreaks and habitat.

Table 9-27 Scenarios: Future of A&B Properties Lands

Crop	*SCENARIO 1: 100% of HC&S Lands Farmed, 10 Year Phase-In		SCENARIO 2: 100% of IAL Farmed, 10 Year Phase-In		SCENARIO 3: 50% of IAL Farmed, 10 Year Phase-In		SCENARIO 4: 25% of IAL Farmed, 20 Year Phase-In	
	Acres	Irrigation Demand MGD	Acres	Irrigation Demand MGD	Acres	Irrigation Demand MGD	Acres	Irrigation Demand MGD
Diversified Crops	6940	28.6	8,000	20 – 43.09	4,000	10 – 21.55	9,000	22.5 – 48.48
Biofuel	14,770	62.08	12,000	35.7 – 60.77	6,000	17.86 – 30.38		
Grazing	8540	17.07	4,000	7.9 – 10.60	2,000	3.98 – 5.3		
Monocrops			3,000	4.05 – 8.7	1,500	2.02 – 4.35		
Koa Forestry			294	1.28	294	1.28		
Fallow/ non-irrigated cover crops	4,650	0	7,606	0	21,106	0	25,900	
Total Plantation	34,900	107.79	34,900	69.03 – 124.45	34,900	35.16 – 62.87	34,900	22.5 – 48.48

*Scenario 1 is based on HC&S's conceptual "Diversified Agricultural Plan" dated March 2016.
IAL lands total 27,294 acres of A&B's 36,000 acre plantation

Figure 9-14 Important Agricultural Lands, Ditches, Service Areas, and Rainfall for HC&S Lands



Kula Agricultural Park

There are nearly 1,500 acres of diversified agriculture production in the Kula area. The largest and most consistently farmed is the Kula Agricultural Park managed by Maui County Office of Economic Development. The Park consists of 31 farm lots ranging from 10 to 30 acres for a total of 445 acres supporting 26 farmers. Crops being grown include vegetables, turf grass, landscape nursery products, flowers, bananas, and dryland taro.¹²⁴ Nonpotable water is pumped from HC&S reservoirs to the Ag Park via the Upcountry Maui Irrigation System which supplies nonpotable water which bypasses the treated municipal supply with a parallel pipeline operated by the MDWS under agreements with EMI and County of Maui. An expansion of 373 acres is in progress, with 71 acres currently being farmed. There is 600,706.22 gpd from A&B Reservoir 40 available for the additional 302 acres of unused acreage under the Kula Agriculture Park Water Reservoir Agreement dated December 30, 2002. Water delivery infrastructure funding will be sought from state and federal sources.¹²⁵ Because surface water sources are susceptible to droughts, additional storage capacity or alternate supplemental sources (recycled or stormwater reuse), as well as the adequacy of the system's reservoir capacity especially along its downstream end, should be further studied.¹²⁶ Farming Upcountry outside the Kula Agriculture Park generally uses municipal potable water supply for all irrigation needs.

Given uncertainty over future agricultural scenarios it is probable that agricultural land use and water demand on Maui will decrease significantly as HC&S cease production and then increase slowly over the planning period as land is converted to a diversified model. Crops that have historically relied on affordable untreated surface water are becoming subject to the U.S. Food and Drug Administration (FDA) Food Safety Modernization Act's more stringent requirements for water quality. Depending on crop, an increased amount of diversified agriculture will likely require treated surface water or groundwater as part of production, with the assumption that the most affordable untreated surface water through plantation irrigation systems may no longer be relied upon as the primary source. Meanwhile, the potable municipal systems will unlikely have the capacity to serve agricultural demands island wide. Although the cessation of sugarcane cultivation is anticipated to free up surface water for more diverse agricultural demands, alternative and appropriate resource use needs to further assessed.

9.4 Population Growth Based Demand - Drought Scenario

Water purveyors plan for seasonal water fluctuations, and in years when precipitation is lower than typical or supply issues occur, voluntary measures and regulatory controls can be implemented to reduce demand. Comparisons of seasonal and annual patterns provide an indication of these fluctuations. For the MDWS system, the highest month of production over

¹²⁴ Maui County OED. <http://www.co.maui.hi.us/621/Kula-Agricultural-Park> accessed 8/31/16

¹²⁵ Maui County Office of Economic Development presentation, Maui County Council Budget and Finance Committee, November 3, 2015.

¹²⁶ State AWUDO, 2004.

the 10-year period 2002 to 2014 exceeded the 10-year average by about 22 percent. The Upcountry district exhibited the greatest variation, but all districts showed significant variation in high month versus 10-year average ground and surface water use. The highest average annual demand exceeded average annual demand for the same period by about 6 percent. Reliable peak month demand is not available for a comparable period. In all cases figures were not adjusted for climate or population variations. Peak demands typically represent increased outdoor use, most notably such as landscape irrigation, as well swimming pool evaporation and similar uses. Rather than projecting increased demand for drought conditions, such as applying a 20 percent drought increase, annual and seasonal fluctuations represent the range of conditions that should be mitigated through water resource and system management and operational measures, controls on water use, community education, strengthened partnerships, etc. For example, working to reduce per capita demand by 8 percent over the planning period would have a significant effect on water demand.

Table 9-28 Water Conserved with 8% Reduction in Per Capita Water Use Rate, Public Water Systems (mgd)

Criteria	2015	2020	2025	2030	2035
Per capita rate target	240	237	232	226	221
Maui Island population	157,087	169,539	182,135	194,630	206,884
PWS demand	37.78	41.95	46.27	50.84	55.15
PWS demand, reduced per capita rate	37.78	40.18	42.25	43.96	45.70
PWS water conserved	0.00	1.77	4.13	6.96	9.57

MDWS. Cal Yr. Per capita rate incrementally reduced over 20 years.

Agricultural crops may exhibit increased ground and surface water demand during drought conditions. Long-term, it is likely that agriculturalists may modify crop types, irrigation methods and other factors to cost-effectively conform water demands and supply.

9.5 Population Growth Based Demand – Climate Change Scenario

For the purposes of this WUPD update the drought scenario provides the population based demand climate change scenario. Water demand may increase in some areas in response to increased temperatures, declining precipitation, and related conditions. Over a 20-year time frame, demand changes due to climate change cannot be reliably predicted. However, vulnerabilities in available supply can be addressed through diversification and resource augmentation.